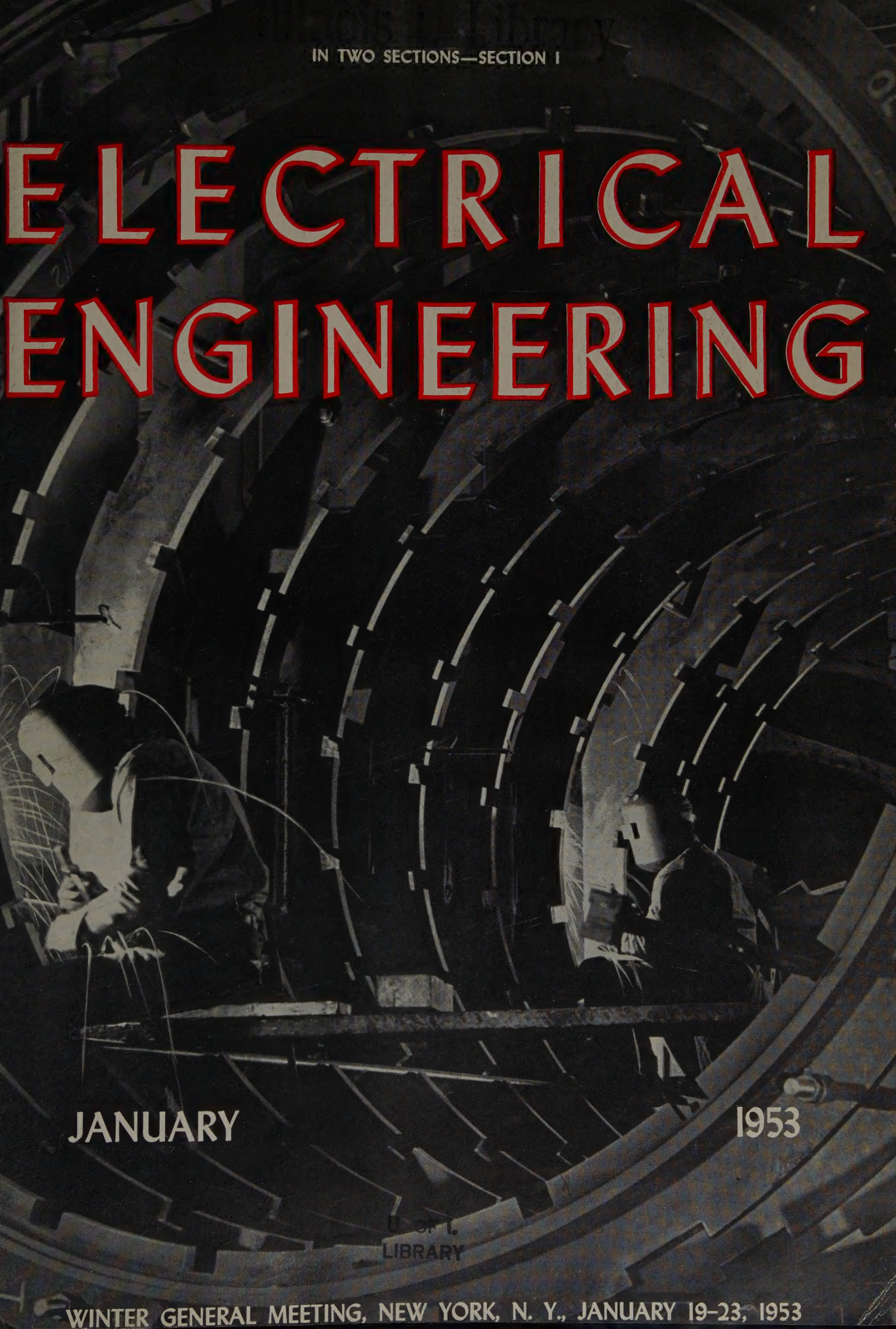
IN TWO SECTIONS—SECTION I

ELECTRICAL ENGINEERING



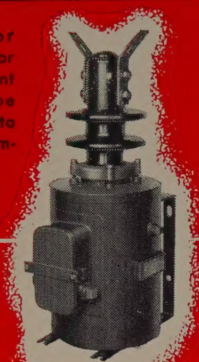
JANUARY 1953

WINTER GENERAL MEETING, NEW YORK, N. Y., JANUARY 19–23, 1953

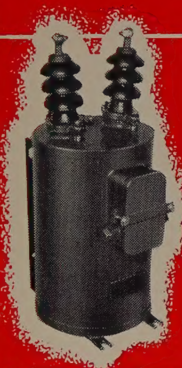
ALLIS-CHALMERS INSTRUMENT TRANSFORMERS

no leaks or contamination

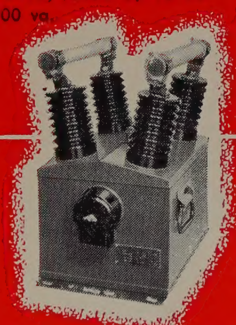
with this Vacuum-Pressure Process



No Leakage or Contamination for the outdoor current transformer, Type KO, rated up to 15 kv and 800 amperes.



High Dielectric Strength for outdoor potential transformer, Type PWD, rated up to 15 kv, 200 va.



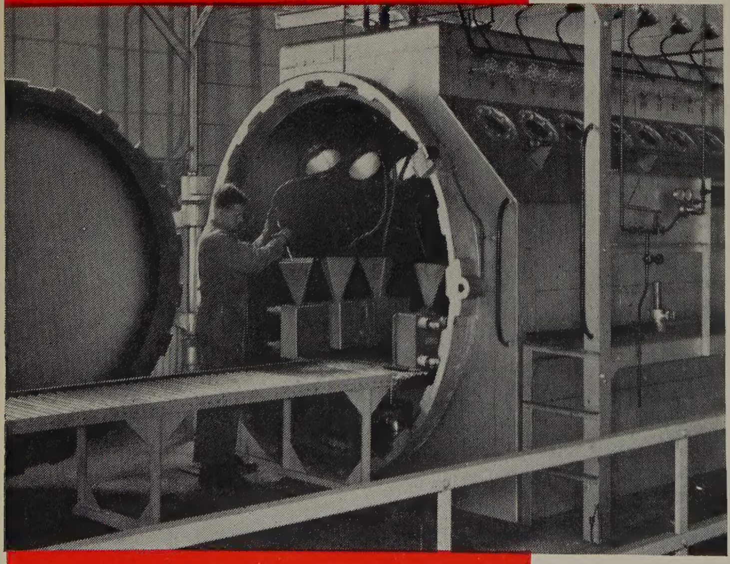
Cuts Maintenance on indoor potential transformer, Type PD, rated up to 14,400 volts, 200 va, fused or unfused.

Allis-Chalmers Vacuum-Pressure System for Compound Filling Instrument Transformers Boosts Safety Factor and Virtually Eliminates Maintenance.

HERE'S AN ALLIS-CHALMERS "extra" that can save you money every day and add years of service to your instrument transformer.

It's the modern A-C vacuum-pressure solid-compound process. In addition to locking out air and moisture, it practically does away with transformer maintenance.

Shown below, the vacuum-pressure chamber does two "life-prolonging" jobs: (1) It leaves the core and coil assemblies bone dry, as a combination of vacuum and heat remove moisture and entrapped air. (2) While under vacuum it fills all voids with compound. This draws hot compound into the innermost parts of the assembly, preventing local ionization and extending normal insulation life.



Solid compound used in the process is chemically stable, has high dielectric strength and is completely free of absorbed gases and impurities. It stops leakage and contamination.

You'll find Allis-Chalmers vacuum-pressure compound-filled units are a sound investment in accuracy and economy. As thousands of users find, they eliminate testing and filtering oil and greatly reduce periodic inspection.

It's easy to see how the benefits of compound-impregnating process will save you money, can save you trouble. Why not contact your nearby A-C district office for more information today. Or write Allis-Chalmers, Milwaukee 1, Wisconsin.

A-3833

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

ELECTRICAL ENGINEERING

Registered United States Patent Office

JANUARY
1953

The Cover: Welders join the ribs and sides of a section of the stator of the largest 3,600-rpm generator ever built, to be shipped from the General Electric turbine plant at Schenectady, N. Y., to the Joppa, Ill., generating station of Electric Energy, Inc. Formed by five other midwestern utilities, Electric Energy, Inc., will supply power to the Paducah, Ky., plant of the Atomic Energy Commission.

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1952 ENGINEERING DEVELOPMENTS

Reviewed by AIEE Technical Committees

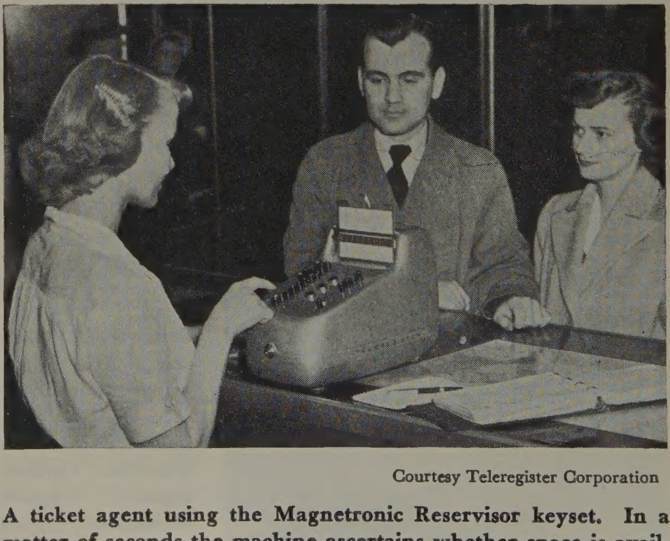
As THE YEAR 1952 draws to a close with the national defense program in high gear, many noteworthy engineering developments and trends have taken place. Twenty technical committees have reported advances in all five broad divisions of Institute activities. The rapid increase in the applications of computing devices in the field of communication switching systems is reported where an air-travel reservation system has been installed, an improved fully automatic teletypewriter message switching system has been placed in service, and a new accounting machine has been inaugurated in the Bell Systems known as AMA (automatic message accounting), where telephone message records for billing purposes are mechanically processed. An analogue computer also has been used for the fast solution of carrier-current transmission problems. The application of computing devices to the quality control of production also has been reported, which brings the age of push-button production control a step nearer. In the field of electric welding, both arc and resistance welding equipment have been improved. In the field of mining operations, there has been an increase in the use of automatic equipment and the application of remote communication and remote control as well as the experimental use of a remotely controlled robot mining machine. In the field of power generation, over 41,000,000 kw will be added to utility systems in the United States during the years 1952–55, and there is a trend toward larger and larger steam turbines of 250,000 kw using 1,100 degrees Fahrenheit steam. The use of aluminum for conductors and the sheath of power cables has been the subject of investigation as well as its experimental use in several types of transformers. Great expansion of transmission systems at all voltage levels is taking place and particular attention is being given to higher voltage systems in the order of 300–400 kv. In the field of science and electronics, there have been many noteworthy developments with primary attention still focused on the transistor. This device is out of the laboratory stage but experimental work to develop new circuitry and economical methods of production continues at an accelerated pace. During the year, the magnetic amplifier has been more widely accepted through a better understanding of saturable core devices as stable, reliable system control elements.

Communication

COMMUNICATIONS SWITCHING SYSTEMS

An AIR TRAVEL RESERVATION SYSTEM utilizing magnetic drum storage was developed by the Teleregister Corporation for American Airlines and placed in operation at La Guardia Airport in Queens, N. Y. This equipment provides practically instantaneous indications of space availability to 54 ticket agents located at remote points. An ultimate capacity of 20,000 flight inventories and more than 100 agencies is provided. The equipment operates on a continuous 24-hour basis. It is an outgrowth of automatic inventory systems and utilizes 1,500 electron tubes and 1,400 twin contact relays.

An improved fully automatic teletypewriter message switching system, known as the *81D1* System, was placed in service by the Bell System for a large air line. Improvements over previous systems of this type include increased capacity for multiple address messages, the expedited handling of urgent messages, and automatic checking of station lines and apparatus for proper operation, as well as more efficient operation, of multistation lines.



Courtesy Teleregister Corporation

A ticket agent using the Magnetronic Reservisor keyset. In a matter of seconds the machine ascertains whether space is available and makes or breaks reservations. It has provided the first large-scale day-to-day commercial use of an electric computer employing memory devices

The use of a new accounting machine was recently inaugurated in the Bell Systems AMA (Automatic Message Accounting) center at Newark, N. J. The AMA system is used by the Bell operating companies in the mechanized processing of telephone message records for billing purposes. The new machine, known as the Tape-to-Card Converter, converts the AMA perforated tape records into punched cards. These cards can then be processed by standard business machines to provide the charge and tax values for each customer-dialed toll message and to print the toll service statement that is sent out with each customer's bill.

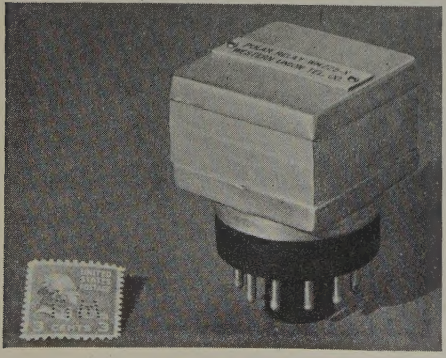
The Automatic Electric Company has announced the development of new telephone-line protective devices. These contain an air gap and a bimetal element. In case of an arc-over due to lightning or a power-line cross, the bimetal element operates to short-circuit the air gap and ground the line. The company also announced a new generator for tone ringing using a single oscillator and switched-in capacitors to produce a continuous sequence of tones.

TELEGRAPH SYSTEMS

A NEW FREQUENCY-SHIFT CARRIER TELEGRAPH SYSTEM providing channels both in and above the voice range, and suitable for use in either private line or TWX service, has been made available and put into commercial service. Carrier on-and-off signals are used for TWX supervision. The equipment is fully electronic and employs miniature components.

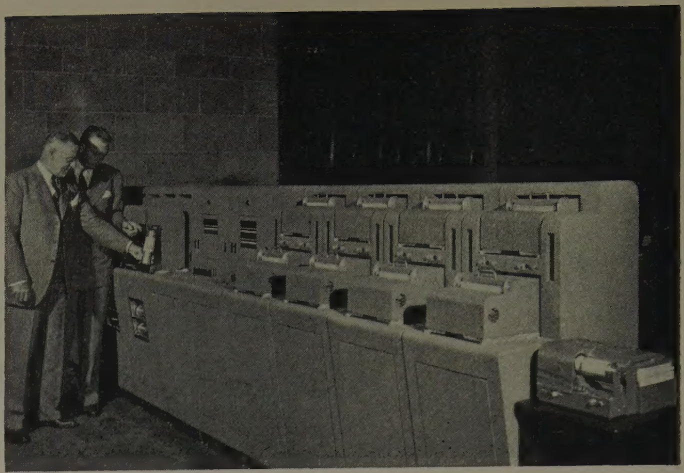
A new polar relay which promises to eliminate practically all of the problems of adjustment and maintenance formerly associated with mechanical relay equipment, has been developed and soon will be ready for use. The armature and contact assembly are completely sealed in a replaceable vacuum capsule which eliminates any possibility of dirt or corrosive gases. The high breakdown voltage assured by the vacuum eliminates any sustaining arc between the points and allows much closer contact spacing. A much higher operating speed is thus made possible and tests have shown efficient operation as high as 5,000 cycles. The use of a ball armature bearing eliminates any possibility of trouble due to bearing wear.

In the field of facsimile, the most important development is a new leased-wire system known as "Intrafax" which provides rapid 2-way facsimile communication between branches or between departments of a commercial organization. Intrafax systems already have been installed



Courtesy Western Union Telegraph Company

Miniature polar relay which features maintenance-free construction. The armature and contact assembly are mounted in a replaceable vacuum capsule which eliminates dust and corrosive gases, and reduces arc between contacts



Courtesy Western Union Telegraph Company

Central control turret of the Intrafax system provided for the Federal Reserve Bank of New York. Eight transmitters and eight recorders provide swift 2-way facsimile communication with 15 member banks in New York City

for a number of companies and are now available commercially. Through the use of a special paper available from the manufacturer, the received reproduction can be used as a duplicating medium to produce additional copies in quantity.

A new *TT4-A* teletypewriter has been designed primarily for operation as a tactical printer in the field. Therefore, mechanisms were provided so that the printer could be operated in any position. These include power operation for both spacing and return of the printer carriage and other devices to safeguard the apparatus against damage under rough transporting conditions. As a result the printer can withstand considerable shock. The usual devices required to set up a circuit for line conditions of previously unknown quantities are also built into the teletypewriter.

As in past years, a great deal of research and development effort is being spent on classified military projects which must necessarily be omitted from this report.

TELEVISION AND AURAL BROADCASTING SYSTEMS

THE FEDERAL COMMUNICATIONS COMMISSION released its Sixth Report and Order on April 14, 1952, making possible the granting of new television station construction permits after July 1, 1952, thereby suspending the "freeze" on the construction of new stations which had been in effect since September 30, 1948. With this lifting of the "freeze," expansion of television service was accelerated, and for the first time commercial television broadcasting stations were licensed for operation in the ultrahigh-frequency band of the spectrum. One such station started operation in Portland, Oreg.

Video interconnection networks using superhigh-frequency radio relay and coaxial cable were expanded to include all but one of the more than 100 television stations in operation. For the first time in history a major part of the United States population thus was provided with direct television coverage of the political conventions, political speeches, and the election returns.

In television studio equipment, improved film cameras

of the iconoscope type delivered the d-c component, gave better signal-to-noise ratio, and had less of a shading problem. Continuous projectors of both 16- and 35-millimeter sizes were demonstrated, making possible the use of a flying-spot scanner, with superior reproduction.

Improved very-high-frequency television transmitters with powers up to 25 kw were produced. Intense development and design on television transmitters for the new ultrahigh-frequency band of 470 to 890 megacycles included the use of triode, tetrode, and klystron tubes.

The manufacture of television receivers continued at a high rate. Major improvements were made in sensitivity, stability, reduced oscillator radiation, better picture quality, and especially the provision of larger picture tubes with the 21-inch diagonal as the most widely used size. Equipment for receiving ultrahigh-frequency broadcasts was actively designed and produced.

The National Television System Committee, which was responsible for the formulation of the present black-and-white transmission standards, was reactivated in the summer of 1951, and in 1952 continued its study and field testing of signal specifications and standards to provide for a compatible color television broadcast service.

JUNCTION TRANSISTOR TETRODE

DURING THIS YEAR, early experimental results have been reported on a modified form of the junction transistor. This new form differs from the old in that two connections rather than one are made to the thin central P-layer of germanium. It is, therefore, a tetrode rather than a triode.

The effect of the extra electrode is qualitatively similar to the effect of the screen grid in a vacuum tube in that it serves to reduce the internal feedback between the output and input circuits of the transistor.

The most interesting result due to this added electrode is a considerable improvement in high-frequency performance. Power gains as high as 11.8 decibels at 50 megacycles, and sinusoidal oscillations at frequencies as high as 130 megacycles have been reported.

WIRE COMMUNICATIONS SYSTEMS

THE TYPE *O* CARRIER SYSTEM has been developed to provide 16 2-way channels on one open-wire pair. The complete system is made up of four 4-channel systems designated *OA*, *OB*, *OC*, and *OD*. The complete system covers the frequency range from 2 to 156 kc. The system is miniaturized and includes many of the features of the Type *N* Cable System, such as the compandor, built-in signaling, and pole-mounted repeaters. It differs from the Type *N* System in that it employs single rather than double sideband. To date only the 4-channel group in the range from 40 to 76 kc has been produced commercially. The other systems will be available in the near future.

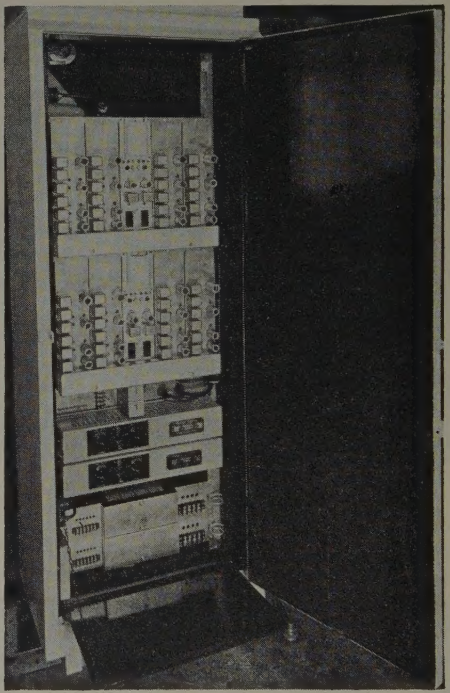
General Applications

LAND TRANSPORTATION

THE MOST SIGNIFICANT DEVELOPMENTS IN THE CITY TRANSIT field have been the extended use of lightweight rapid transit cars with Presidents' Conference Committee type of electric equipment, and the extension of rapid transit operation on surface or open-cut rights-of-way. The East Boston Tunnel extension, largely on the surface, was opened early in 1952. The new Toronto subway, an open-cut line, is nearing completion, and the Cleveland Transit System has placed orders for substation equipment and rolling stock for their new 13-mile rapid transit line.

Plans are being formulated for the extension of Chicago's Milwaukee-Dearborn-Congress subway in the median strip of a highspeed superhighway. There is rapidly growing realization on the part of city and highway planning engineers that public transportation is the only solution to the acute traffic problems now encountered in all large cities. Rapid transit lines and electrically propelled vehicles are essential parts of such plans.

The trolley coach, with improved electrical designs and attractive low operating expenses, continues to be well fitted for the basic surface passenger load. It is also recognized as a necessary aid to the solution of the acute traffic problem in cities.



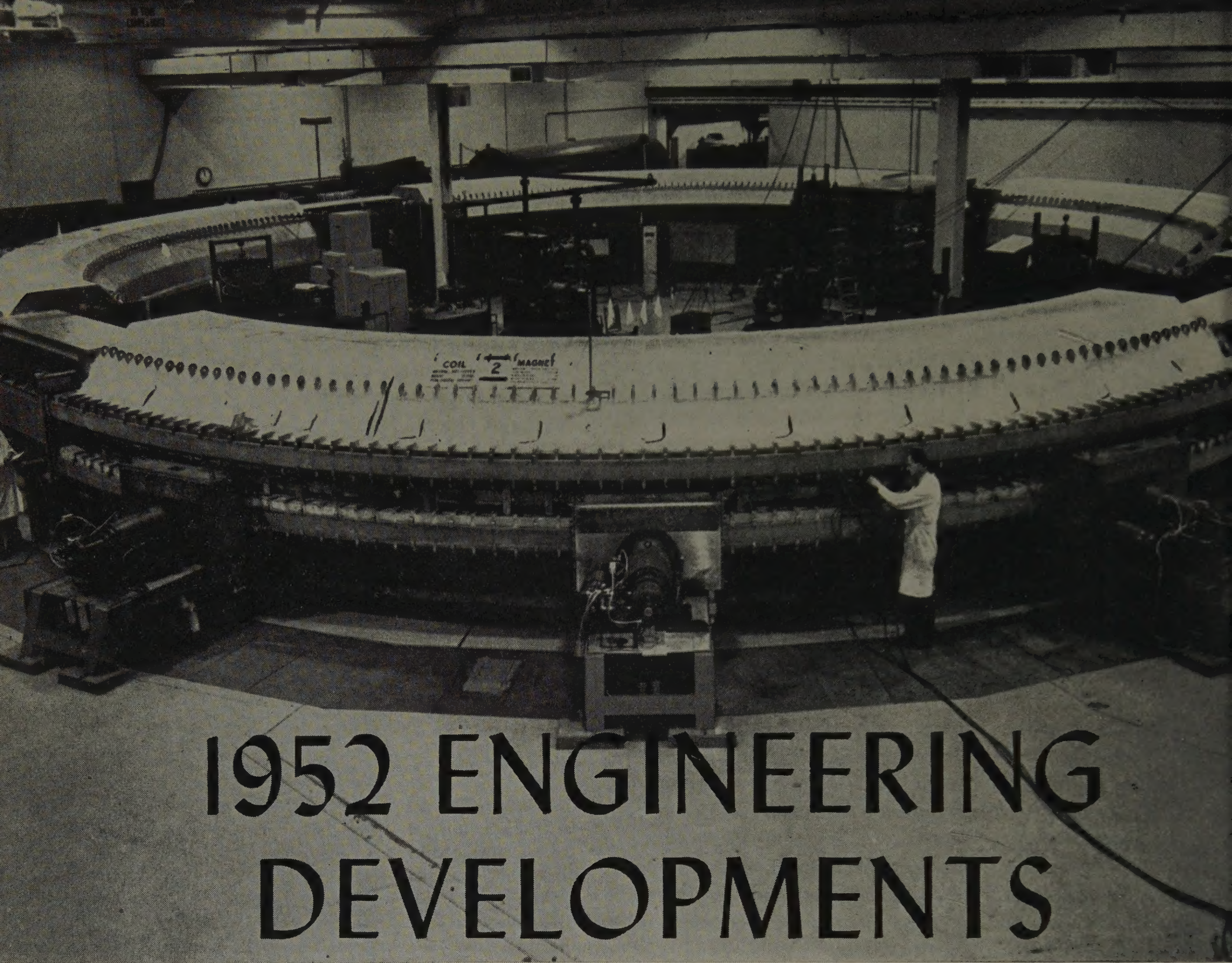
Laboratory model of fully equipped pole-mounted cabinet of common systems O carrier telephone

Courtesy Bell Telephone Laboratories, Inc.

Conversion to diesel-electric locomotives continues on American and Canadian railroads. This year, 65 per cent of freight train service in the United States operated with diesel power, also 70 per cent of passenger train service, and 75 per cent of yards and switching service, now have been converted to diesel operation. Development and refinement of diesel power continues. The same is true with the new gas-turbine locomotive which is now pulling regular trains on the Union Pacific Railroad.

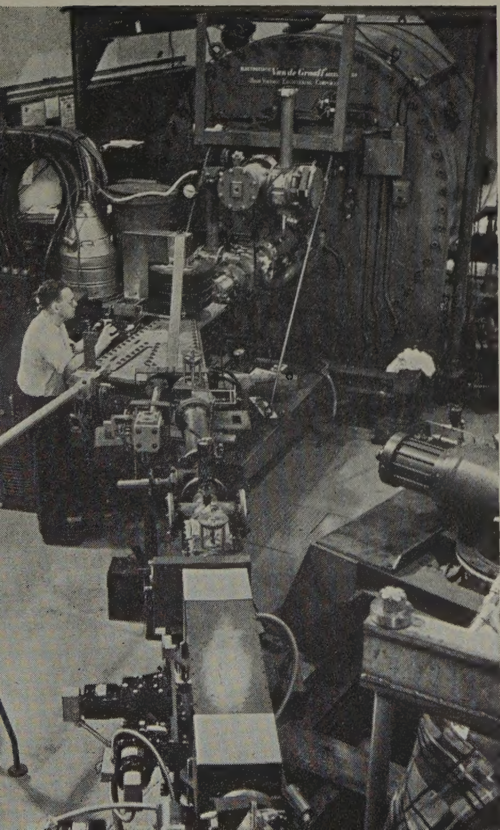
The electric locomotive, particularly the ignitron type, is undergoing severe tests on one Eastern railroad. The

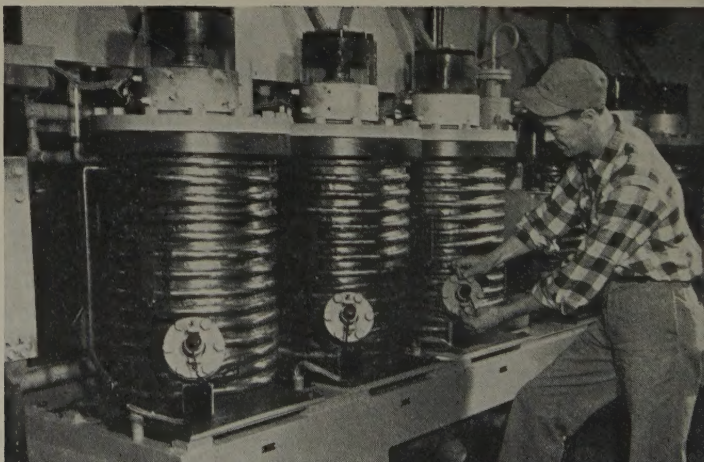
(*Continued on page 16*)



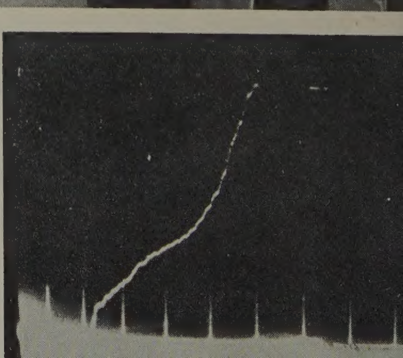
1952 ENGINEERING DEVELOPMENTS

Photos Courtesy Brookhaven National Labora

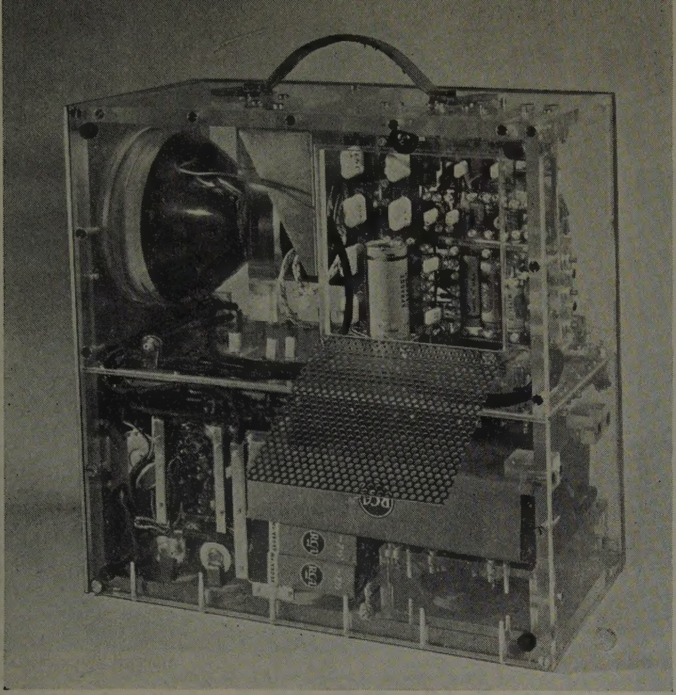




The Brookhaven Cosmotron at the Brookhaven National Laboratory, Upton, N. Y., is shown at top of page. At left is the injection system for the Cosmotron, showing the Van de Graaff generator. Three of the 24 giant ignitron tubes which supply power for the Cosmotron are shown at right. Bottom is a photograph of oscilloscope screen recording 1.3 billion-volt energy achieved by Cosmotron

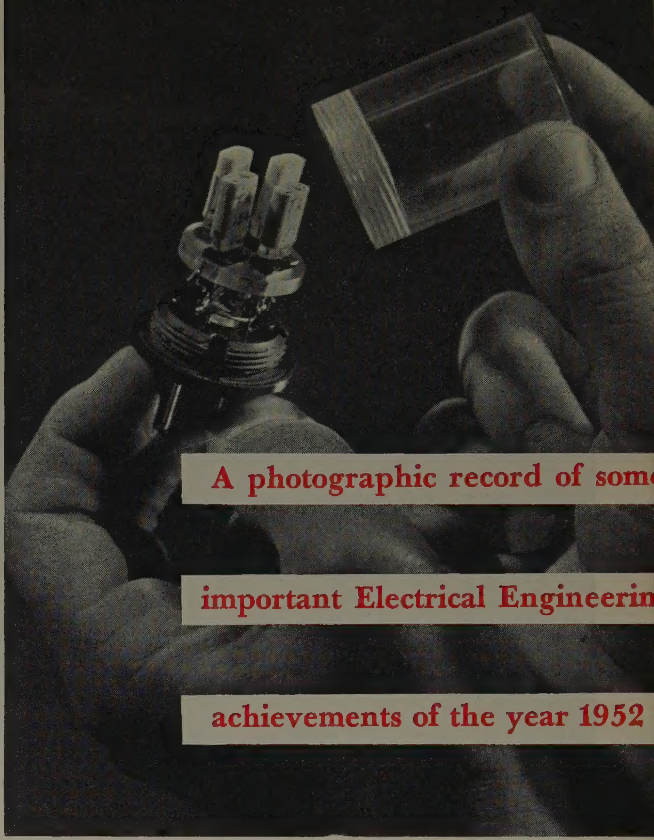


A photographic record of som
important Electrical Engineerin
achievements of the year 1952



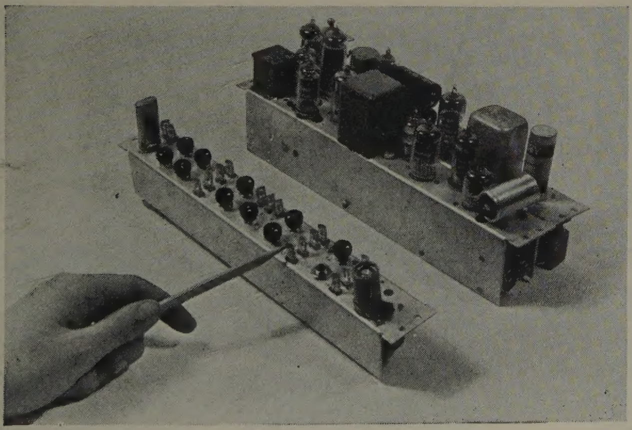
Courtesy Radio Corporation of America

▲ Side view of portable battery-operated television receiver, which uses developmental and experimental transistors and no tubes except the 5-inch picture tube. The single-channel receiver weighs 27 pounds and is about the size of a portable typewriter case



Courtesy Radio Corporation of America

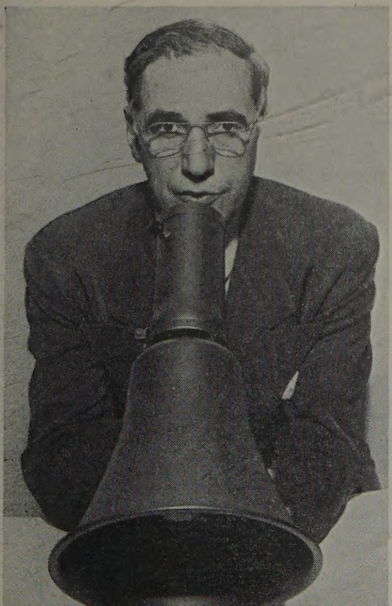
▲ Complete experimental audio amplifier stage in which four junction transistors, mounted on a small plug-in base, perform the combined functions of two or more electron tubes, an output transformer, and other components. Operating off a small low-voltage battery, this transformerless and tubeless audio amplifier can provide sufficient amplification to operate a loudspeaker



Courtesy Radio Corporation of America

◀ One of the units of an experimental "Walkie-Lookie" portable television station designed with developmental transistors is shown in foreground compared with the corresponding tube-equipped unit used earlier. In the developmental model, 17 point-contact transistors perform the functions of 22 tube elements, reducing consumption of the back-pack unit by more than one-third, promising savings in battery size and weight

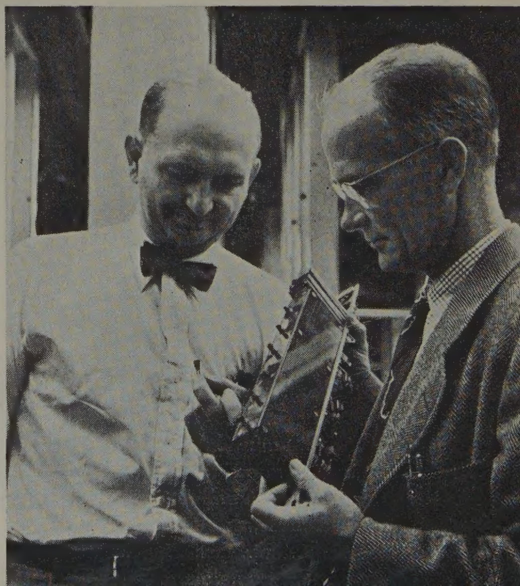
Courtesy General Electric Company



◀ Megaphone using transistors can carry the normal speaking voice farther than most people can shout. Transistors in the megaphone operate from tiny batteries, eliminating use of bulky, high-voltage batteries and the need for an external power supply

▶ F. E. Blount (left) holds one of the transistors which will be used in oscillators to generate electric signals by which the numbers of a called telephone are sent from one office to another. Dr. William Shockley (right) holds the oscillator, which uses six transistors

Courtesy Bell Telephone Laboratories



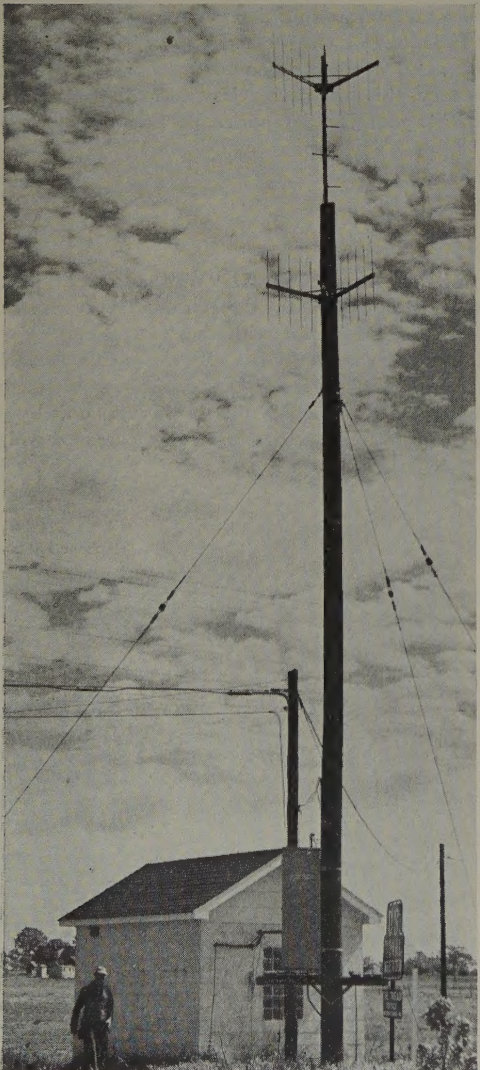
Communication

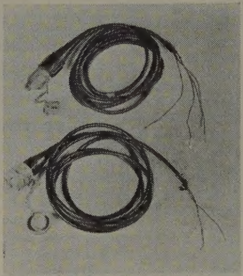
Courtesy Kleinschmidt Laboratories Inc.

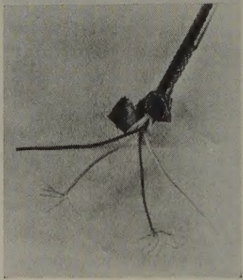
▲ Portable 100-word-per-minute tactical power-driven teletypewriter, weighs 45 pounds and can be operated in moving trucks or planes

Courtesy Motorola, Inc.

▲ Handie Micro-Talkie F-M Transmitter operates on 152–174 megacycle band, weighs under 2 pounds, has range up to 5 miles with more than 25 milliwatts output. Plated wiring is printed on both sides of the bakelite chassis in which holes accomodate leads from top to bottom eliminating crossovers





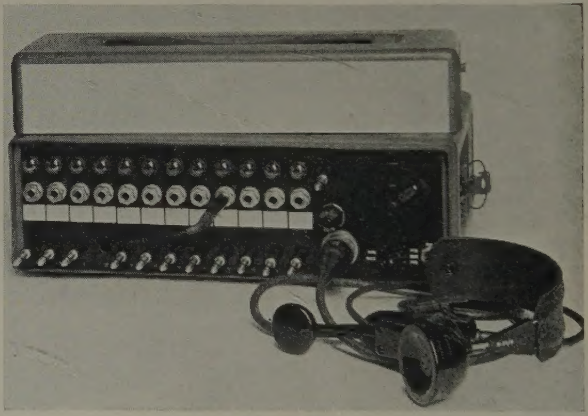


Courtesy Bakelite Company

▲ New polyethylene and vinylite insulated carrier cable has 5 times the frequency range, weighs and costs one-third less than old types

◀ Radio relay system connects rural areas to nearby city's telephone exchange and is in box on pole topped by two television-like antennas. Relay system is connected to automatic dial-switching equipment inside the small building.

Courtesy General Electric Co.



Courtesy Federal Telephone and Radio Corporation

▲ Smallest and most compact Army field telephone switchboard, this 12-line monocord board is used for switching local-battery telephone lines and voice-frequency telegraph circuits

▶ Portable field telephone set has superior transmission features, fits under battle helmet, and "press to talk" switch can be operated when wearing Arctic mitts. The entire set is expected to survive parachute drops with ease and can operate on voice power in emergencies

Courtesy Bell Telephone Laboratories

Tubes

Courtesy General Electric Company

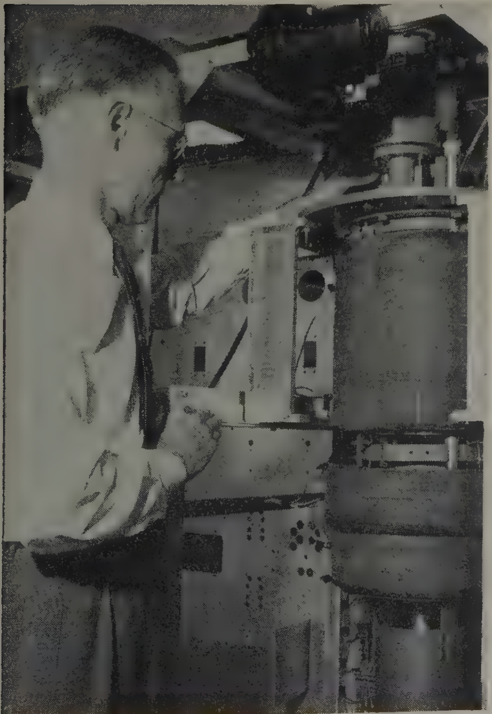
▲ Ultrahigh-frequency transmitting tube being inserted in oscillator cavity is first air-cooled tube designed for ultrahigh-frequency operation up to 900 megacycles with peak output of 1 kw. Ceramic and metal envelope increases its resistance to high temperatures

Courtesy General Electric Company

▲ Mixer tube designed for use in a television tuning unit to tune in both very-high-frequency and ultrahigh-frequency television channels is one of three types which together complete the tube requirements for a combined tuning system for television receivers. The other two are an oscillator and a radio-frequency amplifier

▶ All-metal traveling-wave tube is the first such amplifier ever produced. The all-metal shell affords complete shielding from stray radio-frequency fields. The operating frequency is 5,900 to 7,100 megacycles. The tube operates at 1,200 volts and has a rated output power of 10 watts and a gain of 25 decibels. This reduced voltage leads to a structure that is physically short, resulting in minimum size and weight of magnet. Coaxial lines, at one end of the tube, serve as the input and output radio-frequency circuit connections

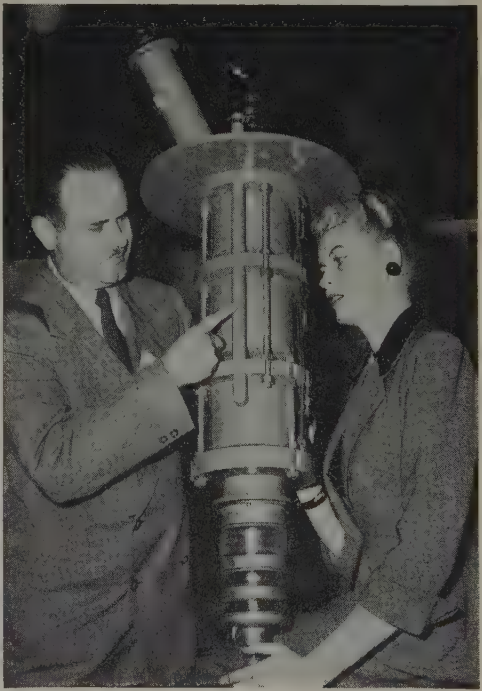
Courtesy Federal Telecommunication Laboratories, Inc.



Courtesy General Electric Company

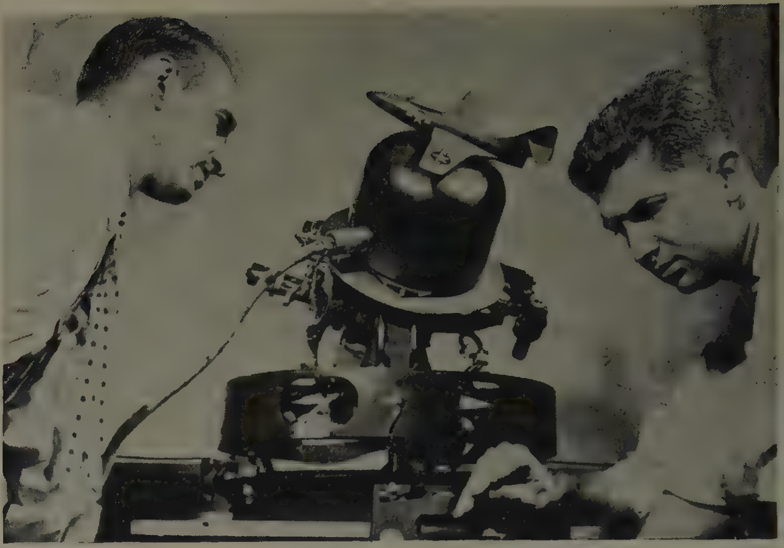
◀ 15-kilowatt klystron tube is adjusted in developmental transmitter. The tube, most powerful amplifying tube yet developed for ultrahigh-frequency television, provides sync output of 12 kw, operating at 750 megacycles, and is rated at 15 kw saturation

▶ Full-scale model of the klystron tube measures $4^1/_2$ feet long and weighs 200 pounds. The tube will be used in one of the first high-power ultrahigh-frequency station in Reading, Pa., and is expected to provide most of the power output needed for widespread coverage



Courtesy General Electric Company

Controls



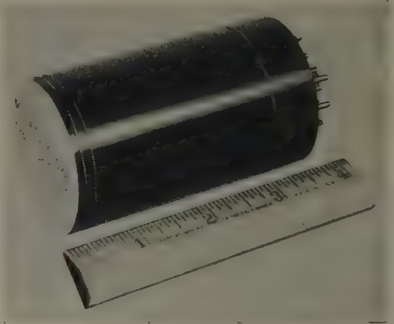
Courtesy General Electric Company

▲ Automatic pilot being tested with airplane flight simulator relieves pilots of 90 per cent of routine flight duties

Courtesy Columbia Broadcasting System

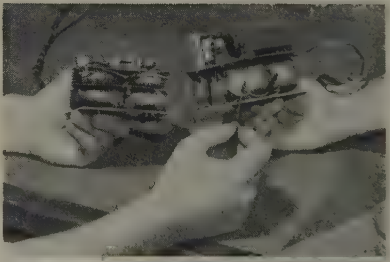
▲ World's largest stage-lighting control installation for new Television City, Hollywood, and only all-electronic system provides flexible and revolutionary television lighting effects

▶ The miniature gyroscope is able to rival the performance of gyroscopes 20 times its size and weight because its internal parts are supported by the buoyancy of a high-density fluid. This type of suspension holds the frictional torque error to an absolute minimum

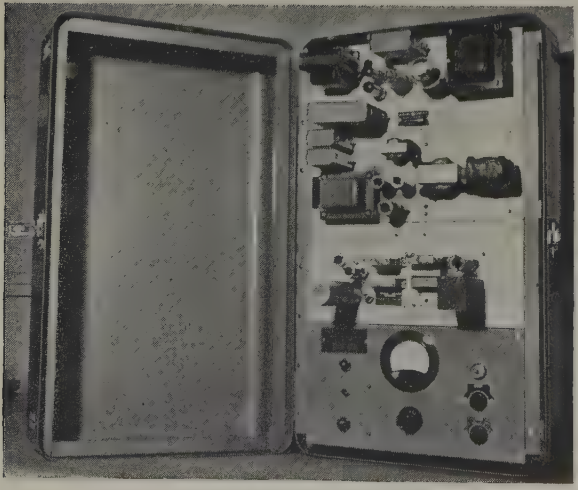


Courtesy Reeves Instrument Company

▶ Two of the new magnetic amplifiers show the great reduction in size which has been made. The one to the left is a 400-cycle system, and the one to the right is a 60-cycle system. Both operate on 115 volts. The new circuits are based on half-wave operation. The magnetic amplifier requires no power supply, has a maintenance and replacement cost of practically zero



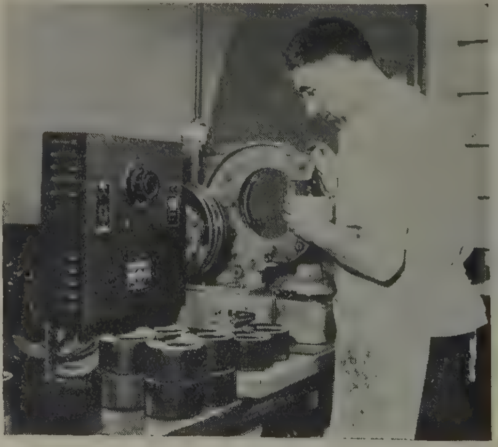
Courtesy U. S. Naval Ordnance Laboratory



Courtesy General Electric Company

◀ Interior view of control cabinet of constant - frequency control designed to hold alternator frequency within 0.001 per cent on motor-generator sets supplying up to 10 kw

▶ Three - quarter horsepower Variac speed control mounted on a toroidal-coil winding machine uses no electronic tubes, making it capable of instant starting, without warm-up



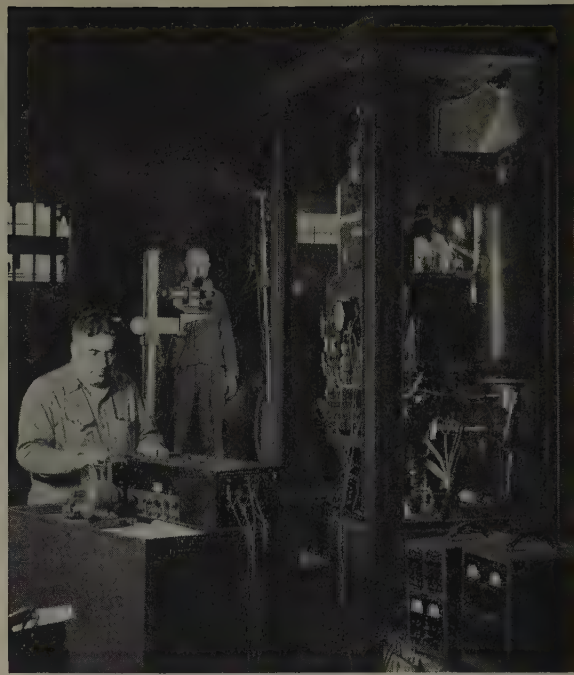
Courtesy General Radio Company

Courtesy General Electric Company

▲ Largest self-cooled transformer built by General Electric in 1952 features a 5-legged 3-phase core. This construction allows maximum winding height with minimum height over core. Core and coils were shipped upright in one-piece tank

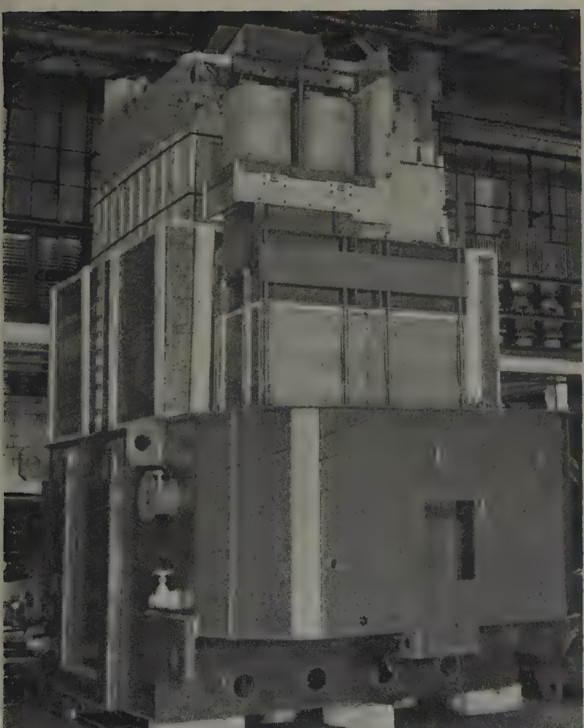
Courtesy General Electric Company

▶ Production - line automatic impulse testing of distribution transformers used as a final check to assure that the transformer will stand up under the most severe service conditions



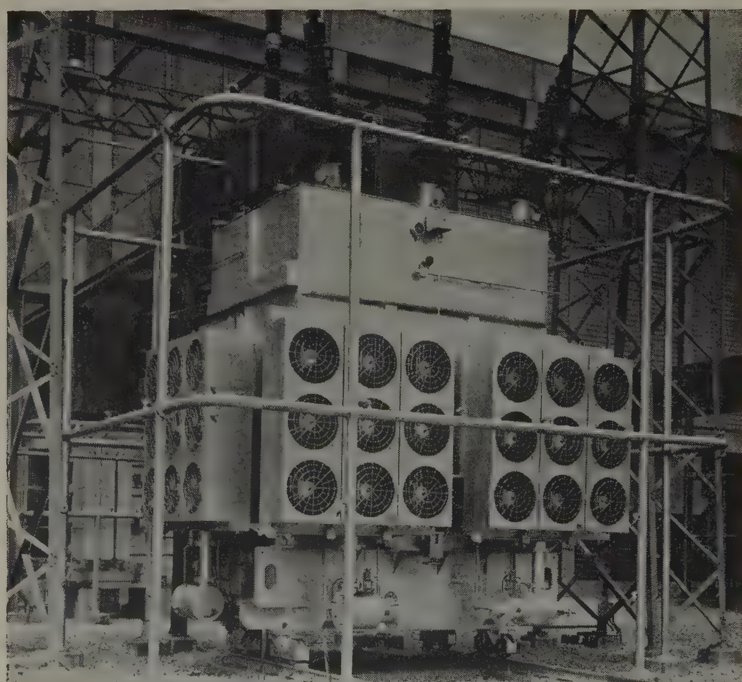
Courtesy Allis-Chalmers Manufacturing Company

▲ High-speed motion picture and oscillographic studies are being made on one of several test models of a hydraulically operated actuator for large circuit breakers. High-speed valves and a hydraulic accumulator make possible multiple reclosings at speeds far in excess of present circuit breaker standards. The unit provides high-speed emergency manual closing and manual positioning of the circuit breaker to any intermediate point. Advantages of sealed hydraulic system are simpler mechanical linkages, and reduced maintenance, wear, and weight



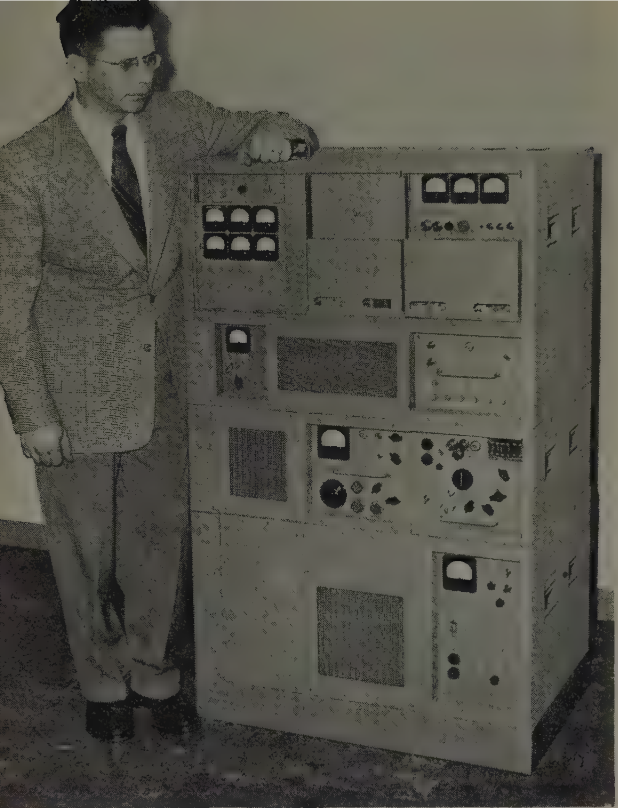
Courtesy Westinghouse Electric Corporation

▲ This 83,333-kva 230-kv single-phase forced-oil- and forced-air-cooling four-winding auto transformer is made for mounting on a special railroad car. Core and coils were assembled upright, as shown

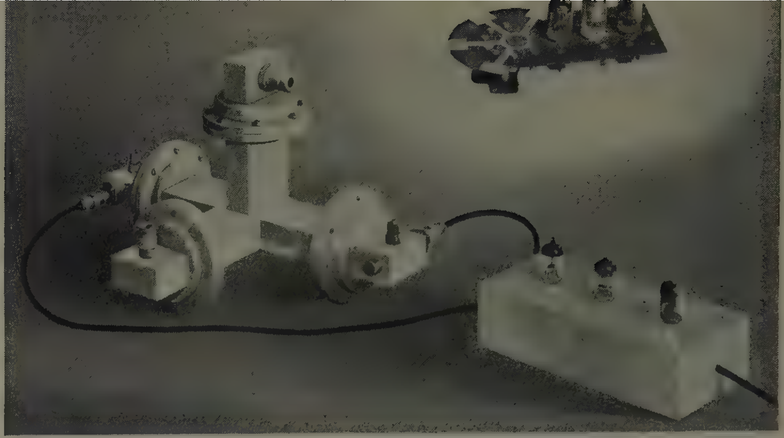


Courtesy Westinghouse Electric Corporation

▲ A 147,500-kva 161-kv 3-phase form-fit forced-oil- and forced-air-cooling transformer is shown. Similar units for 220,000 kva are now under construction. Forced-oil cooling has enabled transformer designers to keep pace with the increase in generator ratings. One manufacturer has built over 40 million kva of forced-oil-cooled units. Eighty of these transformers are for ratings of 100,000 kva or greater



Courtesy Stanford Research Institute



Courtesy Federal Telecommunication Laboratories, Inc

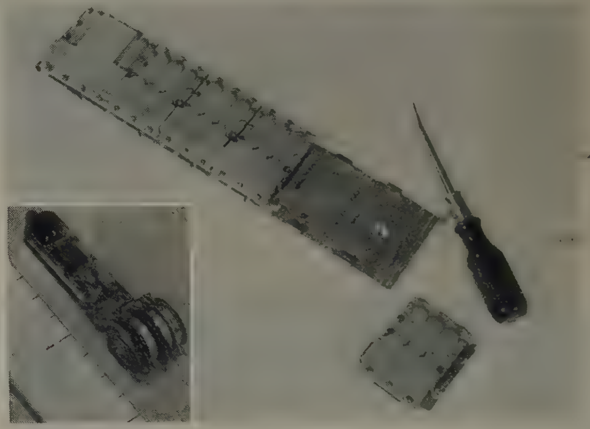
▲ Microstrip method of microwave wiring utilizes a ground-plane system, a base plate that acts as radio mirror to produce a parallel-wire system. Microwave components can be produced at a fraction of weight and cost of machined components previously required. Shown here are microstrip balanced crystal mixer and 3-stage amplifier above and the older wave-guide junction and preamplifier used in conventional microwave installations

◀ Experimental model of high-level single-sideband suppressed carrier transmitter for the Signal Corps covers high-frequency range and incorporates automatic tuning and load matching

Radio Equipment

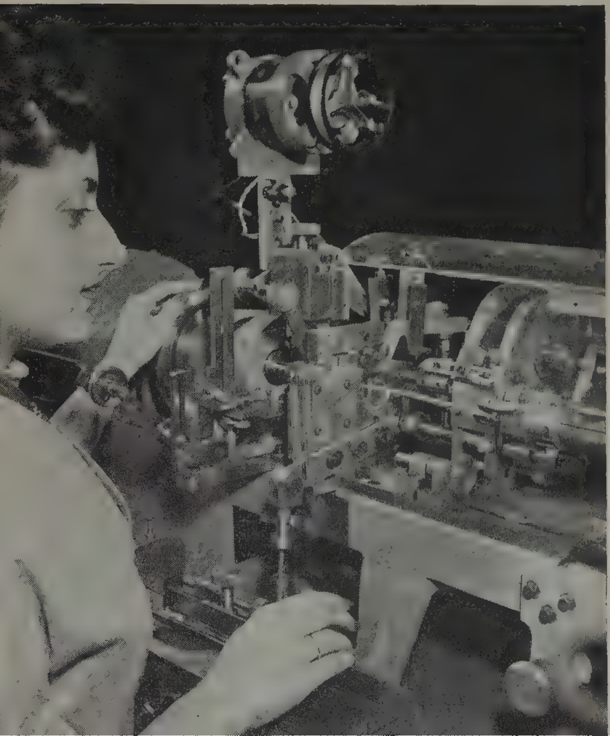
Courtesy Anaconda Wire and Cable Company

◀ All-weather ultra-high-frequency transmission line serves as lead-in from antenna to receiver, is reliable over all channels



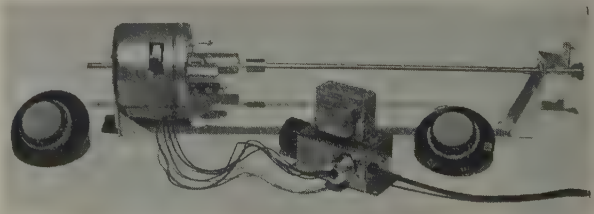
Courtesy Bureau of Ships, U. S. Navy

▲ Standard Subminiature Intermediate Frequency Amplifier developed by Melpar, Inc., for the Bureau of Ships. A typical assembly of building-block units is shown. Various combinations of the several types of units may be made up to obtain the gain and band-width required. (Inset) Method of construction used in the individual stages is depicted. Generally three such stages are contained within each unit. The disk shape of the parts forming the stack was chosen for potential application to mechanized production



Courtesy Bendix Aviation Corporation

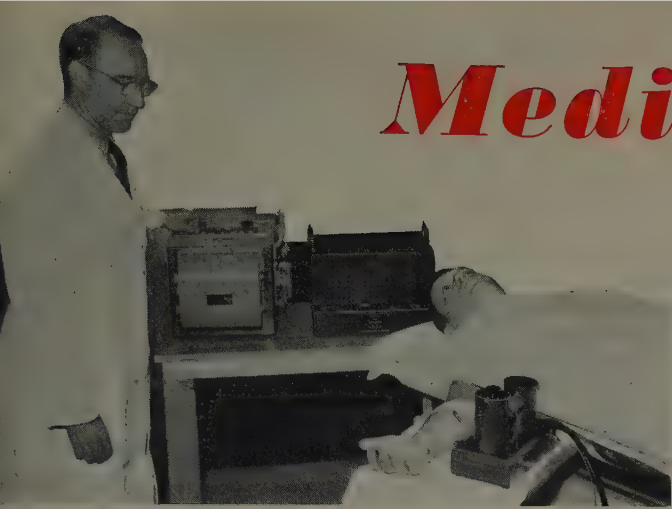
◀ Worker applies delicate adjustment to complex grid winding machine. A key unit in the production of electron tubes, the machine winds tiny strands of gold-plated wire, as fine as 0.001 inch in diameter, on nickel grids for tubes that will perform unfailingly at more than 10-mile altitudes in aviation radar, automatic pilots, and other critical functions



Courtesy General Electric Company

▲ Ultrahigh-frequency translator designed for use in General Electric television receivers is shown with power supply unit, foreground, and two knobs for tuning the set to 3 local UHF stations

Medical



Courtesy United States Army

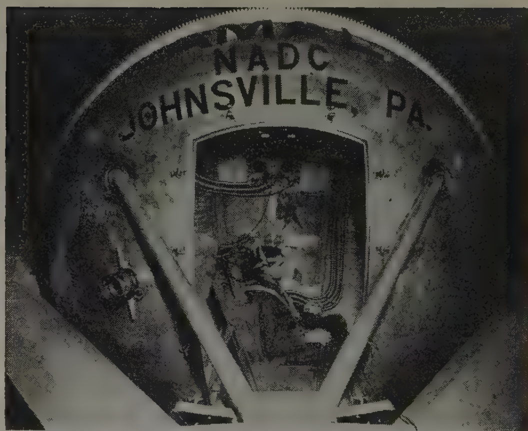
▲ Recording Cuvette Densitometer, developed by National Bureau of Standards, measures cardiac output by the dye dilution method. The instrument makes a continuous record by photoelectric observation of the rate of dilution of dye injected in heart

▶ Electronic finger, known as an ion chamber, is key part of equipment used in planes to detect radiation over atomic blast sites and is far smaller than other gamma-ray detectors

Courtesy General Electric Company

Courtesy General Electric Company

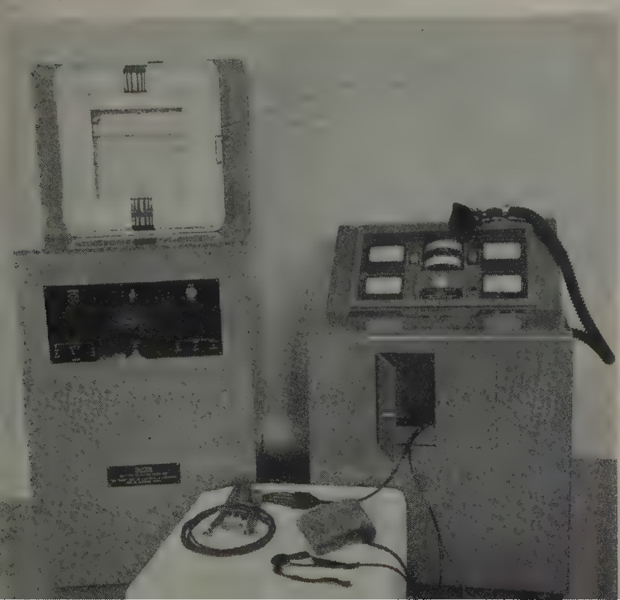
(Left) Improved Cardioscribe features pull-out-type paper drive mechanism which facilitates and speeds reloading and servicing. (Upper right) View of gondola of human centrifuge chamber showing human "guinea pig" with wires and instruments to record measurements of respiration, heart waves, and brain waves. (Lower right) Operation of centrifuge is directed from control desk. On right is turntable to regulate speed and in front of operator is meter indicating force of gravity

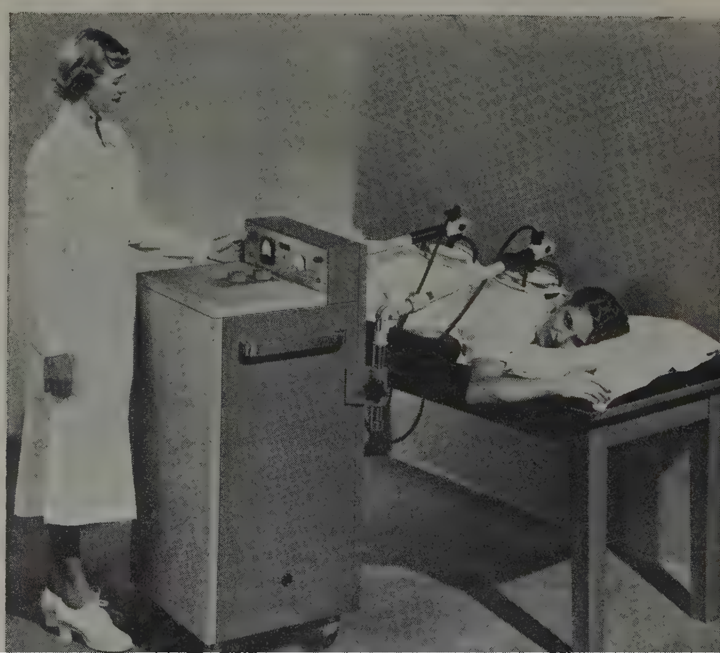


Courtesy General Electric Company

▼ Physiological Monitor automatically records blood pressure, pulse rate, arrhythmia, and respiration rate and volume. Section of the monitor on right is used in operating room to display these variables visually. A second section of the monitor (left) located outside the operating room, contains air supplies, air compressor, and recording unit. (Below right) Diathermy unit, the Inductotherm, generates a controlled heat deep within body tissues with increase of blood supply and aids in relief of pain

Courtesy National Bureau of Standards





Lighting

Courtesy General Electric Company

▲ This 6-foot fluorescent street light has been called the latest development in modern street lighting. The new luminaire provides a constant source of virtually glareless light despite temperature changes and employs four 100-watt, rapid-start fluorescent lamps. Light from the lamps is reflected through a 6-foot plastic housing. The entire fixture weighs about 100 pounds and houses its ballast, making it a compact unit. It will be used in downtown areas and can be operated on series or multiple circuits

▶ New 100-watt lamp bulb is expected to be a popular light source for one- and two-socket ceiling fixtures in homes, apartments, hotels, restaurants, and clubs. The new style bulb has a bowl whose unique shape directs two-thirds of the light upward to the ceiling, creating a pleasing indirect lighting effect. The lower portion of the bowl is covered with a soft-toned, permanent enamel finish which filters and mellows the one-third of the light directed downward. Three concentric rings in the enamel, and a clear spot on the bottom, add decoration, life, and sparkle to the lamps

Courtesy General Electric Company

◀ Cutaway view of the end of one of General Electric's "Rapid Start" fluorescent lamps, showing a close-up of the cathode, which contributes to its improved performance. The cathode is very small and complex, its tungsten wire being triple coiled. It permits smaller ballast size and gives more life for its size than any cathode previously used

Courtesy General Electric Company

▲ This installation of giant fluorescent floodlights at Logan International Airport, Boston, Mass., is the first application of this type of lighting at an airport. Eight 8-foot long tubular fluorescents were installed on the roof-edge of loading section to determine their practicability

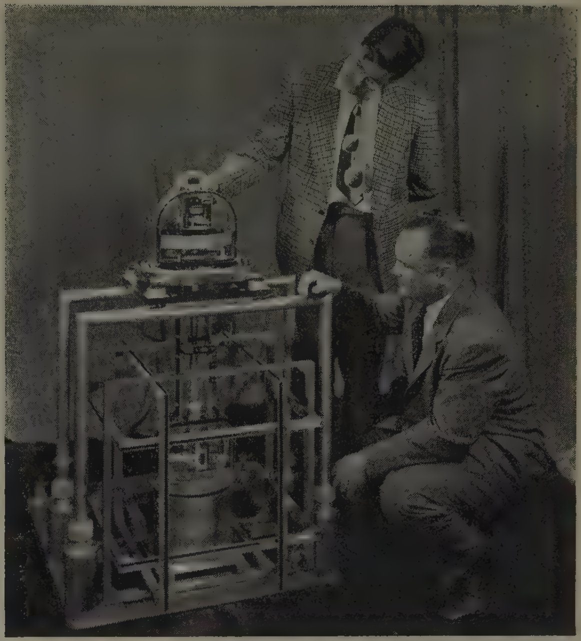
Courtesy Jacksonville Metal and Plastics Company

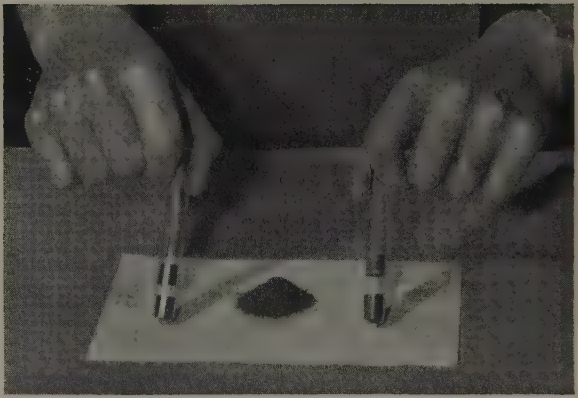
▲ Six bus bars, encased in acrylic voltage barriers, are held to spring contact clips. Plastic prevents arcing or flashover between bars

Courtesy U. S. Naval Ordnance Laboratory

▲ Acoustic depth recorder which is fast in response and small enough to fit into underwater missiles has been developed for recording depth of underwater missiles

▶ Vector airborne magnetometer is designed to measure from aircraft the intensity and direction of earth's magnetic field. It automatically records its findings as rapidly as the plane flies

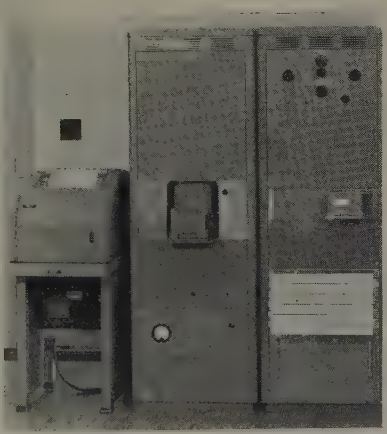




Courtesy U. S. Naval Ordnance Laboratory

▲ Difference in space between magnets in two tubes shows difference in their force. New material in tube to right is of bismanol, other is commercial type

▶ A relay digital computer is being developed by General Electric Company for quality control in manufacturing operations, thus eliminating the need for an inspector and processing the data more than 10 times as fast as it could be done manually. To the left is shown the page printer, the center rack houses the transmitter and d-c power supply, and the right-hand rack contains the sorting and computing relays



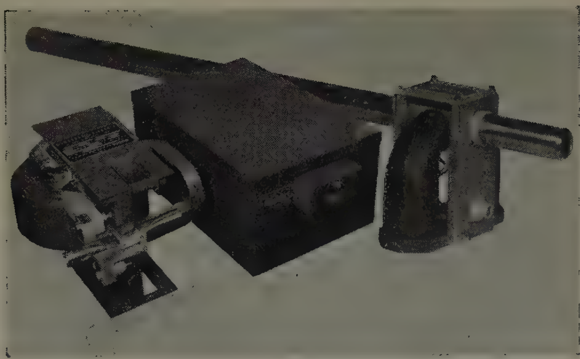
Courtesy General Electric Company

Courtesy U. S. Naval Ordnance Laboratory

▲ Connections are adjusted in the general purpose master control panel for the Model II IBM card programmed calculator. A complex maze of wires and electric connections in the panel makes the calculator a machine which for laboratory purposes is almost the equivalent of an electronic brain. The panel does the work previously done by four separate panels and is noteworthy for its flexibility and smallness of size in relation to large room-size electronic brains

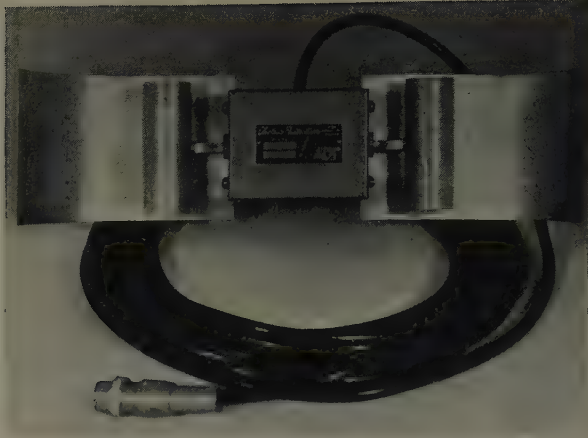
Courtesy Rome Air Development Center, USAF

▲ Runways of Idlewild Airport as seen on the Airport Surface Detection Equipment scope. Antenna covers 360-degree circuit each second, shows runways as smooth dark routes outlined by light, grass plots shaded with light because of beam reflection



Courtesy General Electric Company

▲ Magnetic flowmeter (right) measures molten-metal flow remotely. As metal flows through pipe, it cuts magnetic lines of flux, thus generating voltage proportional to rate of flow. Electromagnetic pump (left) moves liquid metals on principle that current-carrying conductor (the liquid) in magnetic field is acted on by a force. Capacity about 28 gallons per minute



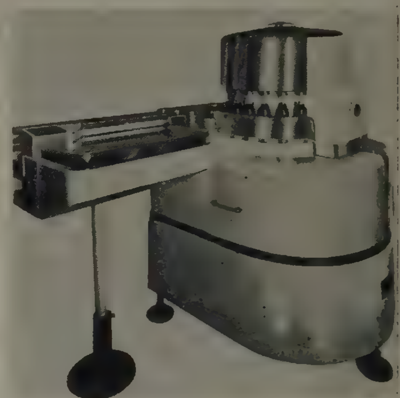
Courtesy ADT Company, Inc.

▲ Magnetostriction transducer is used to produce ultrasonic standing waves at 24 kc in new burglar alarm. Disturbance of pattern by intruder sets off signal to announce the intrusion

Courtesy General Radio Company

◀ Sound-Survey Meter has been developed for sound measurements which do not require a standard sound-level meter, such as noise level from machinery, and simple acoustic measurements. It is shaped to fit the hand but can be set on table or mounted on tripod. Total sound-pressure-level range is from 40 to 136 decibels

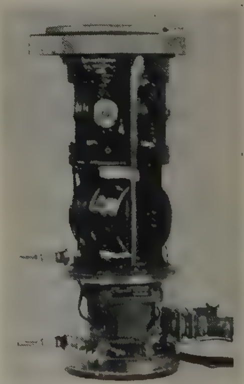
▶ Automatic Beverage Inspection Machine, a combination of electronic, optical, and mechanical elements, is a completely self-contained unit equipped with a reject table and constructed to fit beverage bottling lines employing standard conveyor systems. Speed may be varied over a range from 60 to 150 bottles per minute



Courtesy Radio Corporation of America

▶ Central Station for automatic operation of industrial processes and devices receives signal information on normal and abnormal operations over private wires, records and evaluates it, and takes necessary remedial action. A variety of detection and transmission devices supervise operations

Courtesy ADT Company



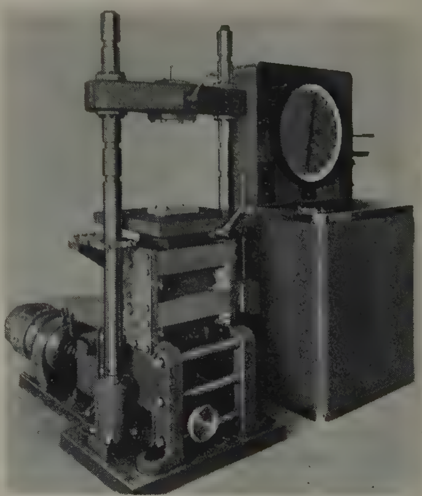
Courtesy Fischer and Porter

◀ Side view of Press-I-Cell, new pressure-measuring instrument as accurate as mercury manometer but more rugged and convenient to use. It can measure pressure with accuracy of one part in 5,000 and has a sensitivity of one part in 15,000. It is compact, portable, temperature-stable

Courtesy Isotope Products Limited

◀ The Gammagage, an instrument to measure corrosion in tanks or pipes, is being used here to measure corrosion in tank. Source of radiation is suspended inside in center of tank and amount of radiation passing through the tank, which depends on tank wall thickness, is measured by gage

▶ Totally new type of universal testing machine of 50,000 pound capacity has an electric weighing system based on resistance-wire strain gages in load cells at base of two vertical tie rods. Testing machine loads are measured by two universal load cells of 30,000 pounds capacity each, at base of the tie rods, and resistance wire strain gage instrumentation of the totalizing circuit type which provides instantaneous response.

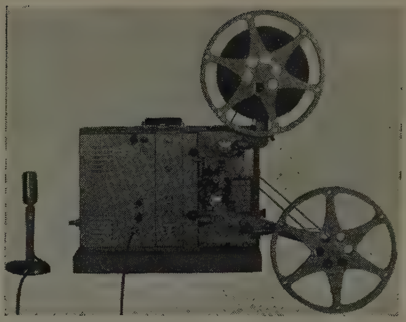


Courtesy Baldwin-Lima-Hamilton Corporation

Courtesy General Electric Company

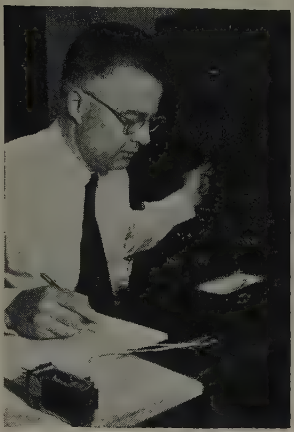
◀ Diesel-electric rail car, Mack FCD rail bus, is driven by 220-horsepower diesel engine connected to generator which drives four traction motors

▶ Magnetic Recorder Projector records sound on magnetic track and reproduces both optical track and magnetic tracks on 16-mm film

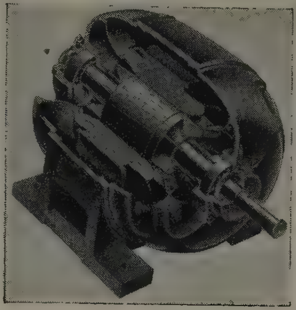


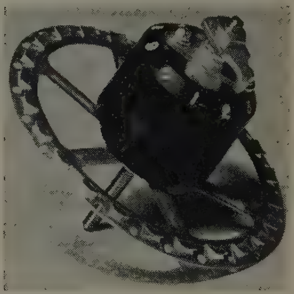
Courtesy Radio Corporation of America

▶ Testing new improved telephone relay, shown in foreground, which can operate in less than 0.003 second and can control as many as 24 different functions at the same time. Improvements in the relay have cut the number of parts from more than 70 to as few as 12. The new type has a life expectancy of one billion operations



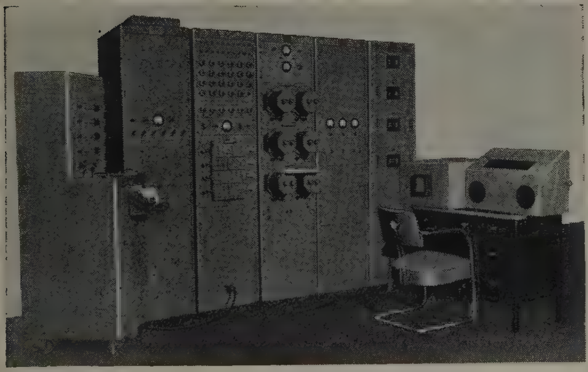
Courtesy Bell Telephone Laboratories





Photos Courtesy General Electric Company

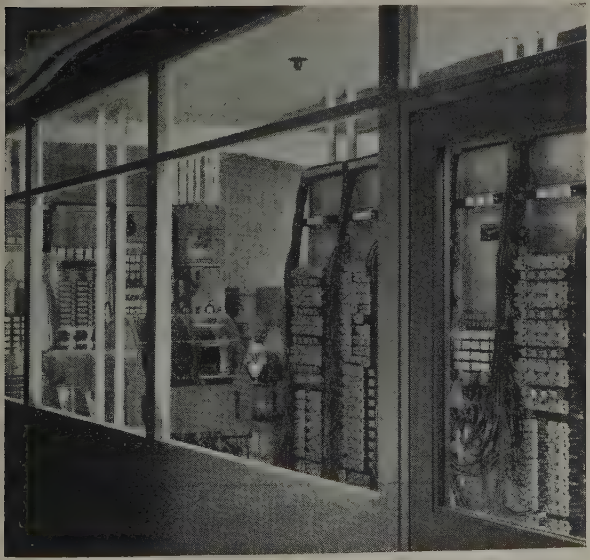
▲ Cross-sectional view of new screenless open textile motor especially designed for positive lint expulsion. Simplified ventilation system provides both cooling and lint expulsion. Lint-laden air enters through endshields and is forced out by cooling fans, shaped to shed lint. (Right) Improved hysteresis brake of Alnico magnets holds constant tension on yarn by magnetic drag instead of friction



Courtesy Reeves Instrument Company

▲ Included in this battery of analogue computing equipment are two all-electronic units which facilitate operation by performing nonlinear computations faster than comparable electromechanical devices. Left, electronic multiplier, center is electronic function generator

▶ Stainless steel storage and mixing tanks in Sylvania tube plant are needed for chemicals used for binding the phosphors to glass screens of television picture tubes. An automatic metering pump mixes the potassium silicate jelling agent and de-ionized water



Courtesy The Teleregister Company

◀ Apparatus room of Reservisor, automatic reservation, system which utilizes magnetic drum storage for automatic indications of space availability for airline flights. The system utilizes approximately 1,500 long-life electron tubes and 1,400 twin contact relays

▶ Betameter, mounted just after couch roll on paper machine, measures, records, and controls all types of continuously produced sheets by radioactivity. Radiation source is placed on one side of sheet and ionization chamber is used to detect amount of activity passing through the sheet

Courtesy Isotope Products Limited

(*Continued from page 3*)

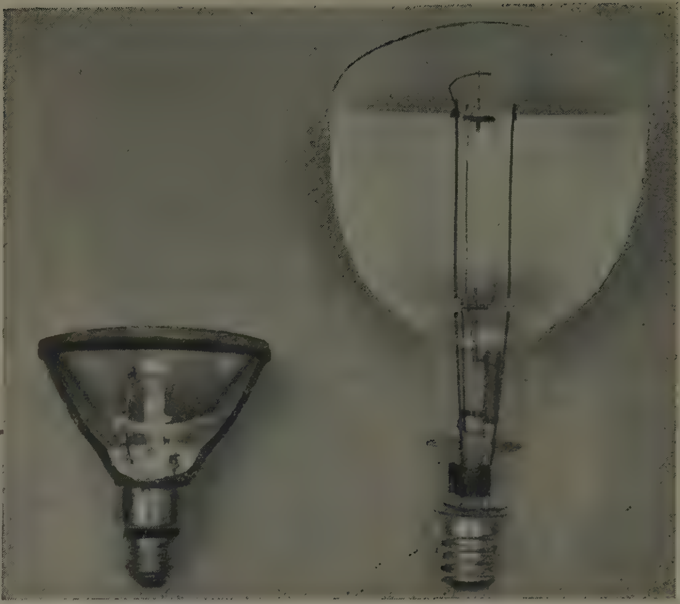
results are encouraging. Europe continues to promote 50-cycle 20-kv electrification, and the French railroads have begun to prove this economic selection for future electrifications, using the rectifier-type locomotive.

PRODUCTION AND APPLICATION OF LIGHT

THE PAST YEAR has been one of steady and continuous development of light sources, the circuits necessary for the control of electric discharge lamps, particularly fluorescent, and the theory and practice of lighting applications.

The announcement and first applications of reflectorized mercury lamps are typical of the growth of specialized light sources. Mercury lamps are now made with integral reflectors of silver or aluminum in the 100- and 400-watt sizes to project light in a manner similar to the well-known incandescent reflector lamps. This construction has been applied to both the straight mercury and color improved mercury lamps.

Two interesting developments in the ballasting of fluorescent lamps were announced during the year. One is a new lead-lag ballast for slimline lamps which reduces size, weight, power losses, and costs over previous designs. The other is a new fluorescent lamp and ballast combination designed for rapid starting which combines the desirable features of the switch-start and instant-start systems and eliminates the less desirable features of both. Announcement has been made also of a circuit for a satisfactory method for dimming 40-watt preheat hot-cathode fluorescent lamps with the first installations planned for the near future.



Sectional view of mercury reflectorized lamps. (Left) A 100-watt pressed-glass mercury lamp produced with either spot or flood lens. (Right) A 400-watt mercury lamp with blown bulb. Both lamps are made with integral reflectors

East Boston tunnel extension which already has an additional extension added in April 1952 and another to Revere Beach ready for construction

Rapid transit system of Shaker Heights, Ohio, which will combine with Cleveland's new 13-mile system now under construction

Advances in the application of light are numerous and varied. An installation that combines simplicity and easy maintenance is available for offices and schools. Low-brightness slimline lamps are combined with baffles of acoustical material which improve both the visual and auditory comfort of the room.

Industry

ELECTRIC WELDING

THERE HAVE BEEN MANY DEVELOPMENTS in the field of electric welding during the past year, including improved designs and performance of welding equipment in both arc and resistance types. A new guide on power supply is available in the report on "Power Supply for Resistance Welding Machines"* by the AIEE subcommittee of the same name, which furnishes much valuable information on this subject for the use of the welder manufacturer, the user, and the electrical utility.

Considerable research has been carried on in the field of electric arcs and instrumentation. A modified RMS Deviation Meter and a Statistical Variation Meter have been developed for use in the study of the welding arc. Improved techniques have been devised for the use of high-speed photography in the study of electric-arc phenomena. Two new instruments are now available for measuring rapid voltage fluctuations of small magnitude.

* AIEE Special Publication *S45*, issued April 1952.

In the field of quality control, much progress has been made obtaining uniform welds of high quality by monitoring the resistance change during spot welding. The effectiveness of the cleaning process is checked regularly in many aircraft plants by taking surface resistance measurements on test samples or by measuring the surface resistance of the production parts. Radiographic examination is used to determine the presence of internal defects. Oscillographic instruments are being used to record the magnitudes of the many welding variables.

GENERAL INDUSTRY APPLICATIONS

Improved designs of NEMA Type 1-A enclosures for textile applications have resulted from the discussions pertaining to suitable enclosures at preceding textile industry conferences, and of special note has been the development by several electric control manufacturers of special loom motor starters. These incorporate many features designed to overcome objections to conventional ordinary purpose enclosures formerly employed. This trend also has been noticeable in the development of improved open ventilated textile-type motors and totally enclosed nonventilated motors for the linty atmospheres.

MINING AND METAL INDUSTRY

Western Mining. One of the most significant developments in this field has been the increased use of technically trained men in mine and surface plant maintenance. This has been brought on by the increased use of automatic hoisting, automatic refinery controls, and other highly technical equipment now being used in mining. The latest advances in electronic work in communications are being applied to underground and open-pit mines, refineries, and smelters in the West. Large power plant installations to handle electric furnaces for the reduction of different metals are being installed. All of these advances call for technically trained engineers in the design and development stage and in operation and maintenance.

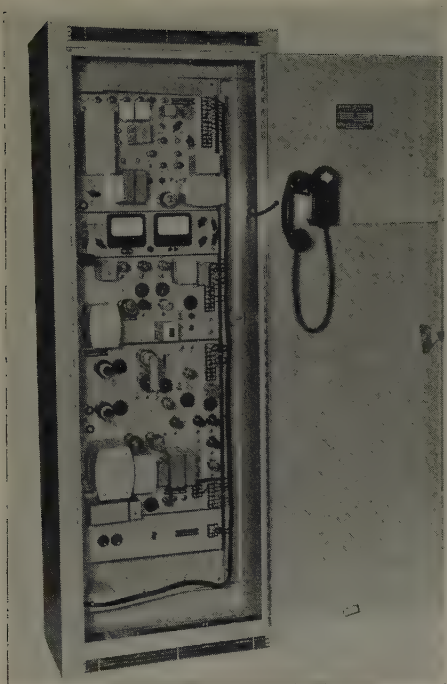
Courtesy Carbide and Carbon Chemicals Company

Electric sensing devices called "Stratascopes," mounted on the outermost cutting teeth of the outer two cutting heads, help the operator of the robot mining machine steer by indicating which strata in the coal seam are being cut and their relation to the center of the hole. The oscilloscope pattern made by the Stratascope when the mining machine is making a normal coal cut is shown on the lower right-hand side. At 1 o'clock there is a slight "blip" as the tooth cuts the first coal in the roof. Proceeding to the left, between 12 and 11 o'clock, the tooth is in shale; between 9 and 8 o'clock, it has encountered very hard bone coal; between 7 and 6 o'clock the deflection is made by hard, thin sections of coal; finally, at 5 o'clock, it leaves the cutting area as it enters the space cut by the adjacent head

A new technique for light and sound conditioning with slimline fluorescent lamps. These lamps operate at 200 instead of the usual 425 milliamperes and are mounted on the ceiling so that they are shielded from normal view by acoustical baffles installed between them

Eastern Mining. Remote communication and remote control are the most significant trends in mining during 1952. Telemetering has been utilized for control of remotely located ventilating fans, using a pair of single wires instead of multiconductor cable. Frequency-modulation carrier-current communications equipment is being used increasingly both for locomotive haulage systems and mine shafts in coal and other types of mines.

The remotely controlled robot mining machine, now being used experimentally by Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corporation, is mounted on crawler tracks, which are driven by a variable-speed electric motor. Four overlapping cutting heads with tungsten-carbide-tipped teeth cut an even hole 10 feet wide by 3 feet high. Electric sensing devices called "Stratascopes" are mounted on the outermost teeth of each of the outer two cutting heads. They are coupled to two polar oscilloscopes which trace the paths of these teeth to indicate which strata in the coal seam are being cut. The machine has produced up to 567 tons of coal in an 8-hour shift, 1,200 tons in a 24-hour day, and 6,000 tons in a continuous week. This production



The top chassis unit is a new and highly selective frequency-modulation carrier telephone receiver substituted for the original receiver in a widely used type of frequency-modulation carrier telephone assembly. The selectivity of this unit provides more than 100-decibel attenuation to all frequencies more than 7 kc from the carrier frequency

Courtesy General Electric Company

represents about 65-per-cent recovery, but ways of increasing this percentage are being devised.

Power

CARRIER CURRENT

Significant Improvements in Handling Carrier-Current Transmission Problems. Programs have been initiated to determine the high-frequency characteristics of all types of 60-cycle equipment including transformers, circuit breakers, metering transformers, lightning arresters, and disconnect switches. Measurements have been made throughout the frequency range 30 to 200 kc.

With knowledge of the characteristics of all items connected to the circuit, calculations have been made of the transmission characteristics of a particular circuit at specific carrier frequencies. A study board has been built which permits the setup and fast solution of almost any problem in carrier transmission.

The analogue computer has been used also for solving this same problem. It produces a plot of the transmission characteristics of the circuit versus frequency which can be used to evaluate the expected performance at any particular frequency over the given path.

The handling of carrier propagation problems in a way which will permit solution through the use of a calculating board or computer marks a major milestone for the carrier industry. It permits closer attainment of the long-sought goal of separating circuit performance problems from equipment performance problems.

The increasing use of power-line carrier facilities which has brought about the need for multifrequency coupling has verified the importance of the broad-band aperiodic coupler described in last year's résumé of developments (*EE, Jan '52, p 18*) and has also pointed out the need for broad-band carrier traps.

A broad-band trap for low current ratings has been developed. This trap has about 10 times the inductance of presently used traps and a much lower Q. The result is a very broad resonance characteristic.

This trap provides excellent blocking of the entire carrier band from 50 to above 200 kc. Its application to power-line circuits provides good isolation of stations or tap lines for all carrier channels that may be on the circuit. One broad-band trap of this type therefore, will do the work of several narrow-band units.

Currently, the broad-band traps are being manufactured for use in power-line circuits carrying 100- and 200-ampere leads.

Protective Relaying by Microwave. Directional-comparison relaying and transferred-trip relaying functions have been multiplexed on 960-megacycle microwave equipment by means of special high-speed frequency-shift tones. Two terminals of this equipment have been in regular operation for more than 6 months for the protection of a 132-kv transmission-line interconnecting two major power systems. In addition, full duplex voice communication is provided between the terminals. The transferred trip is for protection of a transformer bank. An additional spare tone channel is used for alarm.

Frequency modulation is used for the microwave channel with four tones multiplexed above the voice frequencies. Power for the equipment is obtained from the station battery by means of a rotating machine.

Carrier Pilot Relaying for Long Cables. Frequency-shift crystal-controlled equipment has been furnished for protective relaying of a long cable section where the carrier-current attenuation is so high that the shorter range, conventional pilot relaying equipment cannot do the job. Directional-comparison and double-channel transferred-trip equipment operating in the 30- to 70-kc range is used for the protection of a 132-kv cable approximately 12 miles in length.

Some sacrifice in speed of operation was tolerated to secure a greater operating range while retaining the degree of reliability desired for protective relaying. In addition, a close frequency spacing is permissible because of the high selectivity of the equipment.

Selective Telephone Receiver. Greatly improved selectivity for existing telephone equipment has been made possible recently by a highly selective frequency-modulation telephone receiver which is interchangeable with predecessor units. The primary selectivity of this receiver is obtained by means of a filter unit which precedes the first amplifier, thus providing more than 100-decibel attenuation of all frequencies removed from the carrier by more than 7 kc. The filter unit is factory-tuned to any frequency within the 50- to 200-kc band and has an unusually high stability.

Carrier-Frequency Hybrid. More effective use of the carrier-current frequency spectrum has been made possible recently through the development of the new radio-frequency hybrid units. For example, with crystal-

controller frequency-shift channels, where 0.5-per-cent frequency spacing is used, combinations of several transmitters and receivers raise problems of mutual loading and intermodulation. These problems are overcome through the application of radio-frequency hybrids.

A Flexible New Line of Power-Line Carrier Equipment. A new line of carrier equipment with increased flexibility has now been designed to give more functions in a given frequency spectrum under operating conditions encountered in the field. The new line of apparatus includes frequency-shift, relaying, and communications equipment.

The frequency-shift transmitters and receivers in the new apparatus are crystal controlled and have very high selectivity to permit maximum utilization of the carrier spectrum. They are suitable for telegraphic functions such as telemetering, supervisory control, remote and transfer trip, and load control. The transmitter and receiver are both capable of operation from either 120 volts alternating current or 60-cell station batteries.

Standard assemblies are available for both distance and phase-comparison relaying, for indoor or outdoor installation, with and without push-to-talk communication, with and without filament failure alarms, and for both 60- and 120-cell station batteries. In these assemblies, an improved design of the relay receiver permits operation over 40-decibel channels and provides faster operation with more than ample relay blocking current. The new phase-comparison relaying assemblies include an improved design of electronic relay control unit. This control unit uses no thyratron tubes and provides a phase-shift delay adjustment to permit the phase delay introduced by equipment and transmission line to be compensated.

To insure complete independence from loss of communications during an a-c power failure, the new line of equipment is designed for operation from station batteries. The new line of apparatus includes single-frequency (simplex) assemblies, with both manual or automatic control of carrier, and 2-frequency (duplex) assemblies. Code bell or dial selective calling is available. The dial selective assemblies include a complete automatic switchboard, which uses the carrier current as a trunk between stations, and provides dial tone, busy signals, revertive ringback, and other features.

The nominal transmitter output is 10 watts and the receiver sensitivity permits operation, in the absence of noise, over channels with greater than 90-decibel attenuation. The receiver input circuit contains high-selectivity filters which attenuate undesired signals 8 kc away by 90 decibels or greater. The duplex assemblies include a new design of electronic 4-wire termination or "hybrid" which gives greater return loss (that is, signal level at a remote telephone extension) for a given amount of unbalance of the circuit. The automatic simplex assemblies include a new design of electronic transfer unit with an anticipator circuit which minimizes the transients or clicks which have been objectionable in previous designs.

INSULATED CONDUCTORS

The use of aluminum for conductors and the sheath of insulated cables was the subject for investigation by many of the subcommittees. The copper situation relative to deliveries caused an upswing in the actual use of aluminum for the conductors of cable. This use accelerated the development of techniques for connecting the conductors and for handling the cable expansion under loading conditions. During the year, installations of cable with aluminum conductors were made for both secondary and primary voltage operation. Installations of high-voltage cables with aluminum sheath were planned for both the United States and Canada.

Work on the characteristics of cables has continued to revolve around the establishment of sound fundamentals for determining the rating of cables. The development of apparatus and techniques for determining the resistivity and moisture content of soils was actively pursued during the year and considerable progress was made.

An extensive study of the use of limiters and fuses for secondary systems has continued during the year and considerable progress has been made in this important subject.

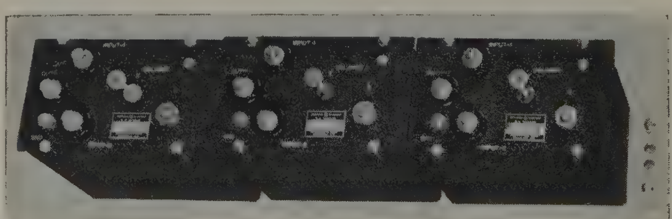
POWER GENERATION

Prime Movers. Over 41,000,000 kw will be added to United States utility systems during the years 1952–55, plus 1,000,000 kw already scheduled for 1956. This tremendous scheduled installation will raise utility generating capacity from 75,544,000 kw as of December 31, 1951, to over 116,000,000 kw at the end of 1955. The national load factor is expected to increase from the current 60 to over 64 per cent.

This growth is reflected in the maximum size steam turbines that will be installed. The largest announced to date is the 250,000-kw unit using 1,100 degrees Fahrenheit steam. The highest steam temperature offered to date is 1,150 degrees Fahrenheit. This is a milepost in the never-ending struggle to achieve maximum thermal efficiency.

The acceptance of reheat units continues 1,000 degrees Fahrenheit throttle temperature with reheat to 1,000 degrees Fahrenheit being the most widely used. While reheat units will only be about one-half the number of straight regenerative units, from a capacity standpoint the reheat units represent more kilowatts than the straight regenerative units. The trend of one boiler supplying one turbine on a unit basis is standard practice. Outdoor and semioutdoor installations of steam units appear to be moving farther north despite unfavorable prevailing weather conditions.

In the hydroelectric field, increased capacity has also been installed but percentage-wise is not as rapid in growth



Courtesy General Electric Company

Three carrier-current reactance-balance hybrid units mounted on a 2-rack unit base for standard 19-inch rack mounting

as the thermal plants. Energy-wise, the proportion of hydroelectric generation is falling off.

Gas turbines are appearing in increasing numbers though, on a nation-wide basis, they are still not a significant proportion of the total capacity. There are 20 central station gas turbines now running or projected for installation by 1954, varying in size from 3,500 to 15,000 kw.

Difficulties have arisen in burning residual fuel oils due to the ash containing vanadium and sodium. While no practical solution has yet been reached, designers are confident that additives probably will be the ultimate solution.

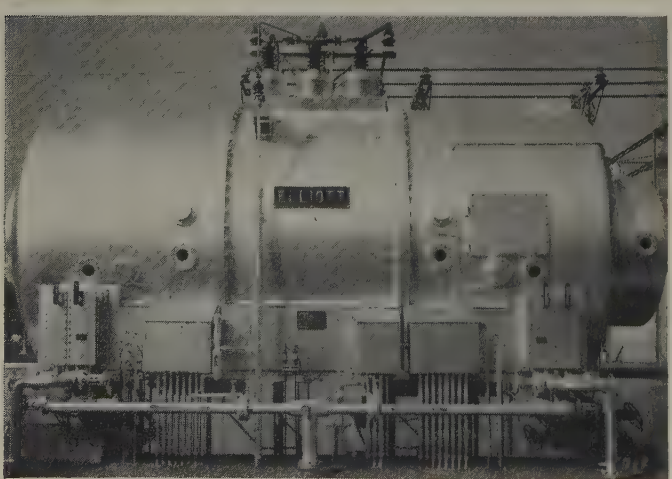
Coal-burning experiments are being carried on in different parts of the world but are still in the developmental stage. However, some groups express confidence that coal-burning gas turbines will be a practical reality in the future.

Excitation Systems. A continuing increase in the use of the rotating-type amplifier combined with the static voltage regulator highlights the recent developments in the excitation systems. The operating record of several installations, as well as the results of a series of comprehensive tests on the actual power system, demonstrate clearly the improvement in the stability and reliability which can be obtained with a proper installation of a modern system of excitation and voltage regulator.

A most recent development in which a multistage magnetic amplifier is used in a static voltage regulator promises to fill the need for a simple, sensitive, fast, and rugged regulator which should permit nearly the ultimate performance of the exciter.

Hydroelectric Generation. Among outstanding developments in the hydroelectric field was the placing in service of the first outdoor hydroelectric power station in northern Quebec, Canada, thus extending very much farther north this technique of development. A further interesting development is the driving of what is believed to be the largest power tunnel ever built in North America, the 51-foot rough diameter, 46-foot finished diameter, tunnel for the Sir Adam Beck–Niagara generating station Number 2 of the Hydro-Electric Power Commission of Ontario. There will be two of these tunnels in this further development of Niagara power.

In the equipment field, the most interesting development is the pump-turbine unit ordered for the Hiwassee development of the Tennessee Valley Authority. When operating as a turbine this unit will have a capacity of 58,000 kw. When functioning as a pump it is understood it will pump almost 4,000 cubic feet per second against a static head of 205 feet, a marked step forward in such dual-purpose units.



Courtesy Elliott Company

50,000-kva synchronous condensers with low reactance, high exciter response, and high momentary overload capacity

PROTECTIVE DEVICES

In the lightning protective devices field there are three developments of interest during the past year. The first consists of unit combinations of distribution-expulsion-type lightning arresters and fuses for 7,200/12,470-volt rural service. Also, distribution-expulsion lightning arresters rated 18 kv for 14,400/24,900-volt rural service are being produced. A third development consists of mounting valve-type distribution lightning arresters on distribution transformer tanks in such a manner that a gap external to the arrester normally isolates it from line potential, thus reducing the possibility of radio interference and other effects which may arise due to the line end of the arrester being normally energized.

In the field of fault limiting devices a pioneer installation in the United States has been made of ground fault neutralizers on generator neutrals. For the first time, generators connected in a unit system with their step-up transformers were neutral grounded with ground fault neutralizers. Neutralization of ground faults was effected to fractional ampere values.

This method of grounding appears particularly suited to large units as it offers an opportunity to continue operation for a limited period after an insulation failure with a minimum danger of further internal damage. This feature provides dispatchers with time latitude for the most advantageous replacement of the unit with other generating capacity.

Another proved advantage of this application is the high sensitivity to the detection of a localized deterioration of insulation even with the generator system in serviceable condition. Two prominent cases of record are the detection of a cracked low-voltage bushing on the transformer and a temporary contamination of surfaces of outdoor bus supports. This feature provides for the maintenance of the system insulation to the highest reliability.

This sensitivity further provides for a maximum reach of alarm and protective devices toward the generator neutral thereby ensuring a nearly complete supervision of the generator insulation.

ROTATING MACHINERY

The outstanding developments in the field of rotating machinery include an 83,000-horsepower synchronous motor, special 50,000-kva synchronous condensers, and unusually large turbine-generators. The motor has been tested, and will be connected in tandem with another

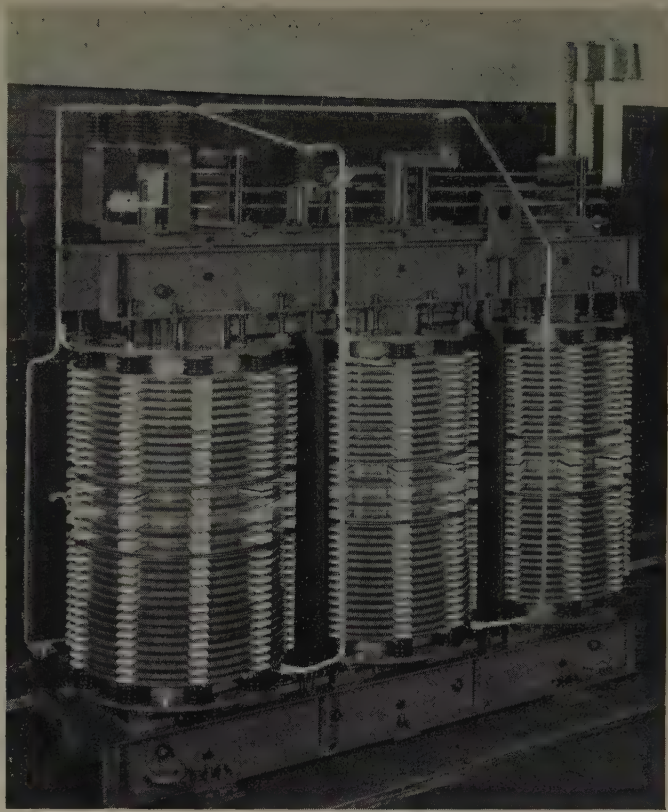
83,000-horsepower synchronous motor and two 25,000-horsepower induction motors to form a 216,000-horsepower drive for the new propulsion wind tunnel being built by the United States Air Force at the Arnold Engineering Development Center near Tullahoma, Tenn.

The first three of four special 50,000-kva hydrogen-cooled synchronous condensers have been placed in service on the system of the Bonneville Power Administration. These machines have unusually low transient reactance, an American Standards Association exciter response rating of 6, and are capable of delivering 120,000 kva for 10 seconds, for the purpose of improving their contribution to system stability during fault conditions. These synchronous condensers are designed for mounting on a grade-level foundation without pits below the machines, in order to minimize the cost of the foundation.

TRANSFORMERS

An interesting development is both the experimental and commercial use of aluminum in some transformers. It has been substituted in dry-type power transformers, sample regulators, and distribution transformers.

A 500-kva 3-phase dry-type transformer having Class *B* insulation is shown. It operates at 2,400 to 480 volts and is delta connected. All windings and leads were made of aluminum and no copper was used. Because of its lower conductivity, an aluminum conductor must have, for a given current, about 60 per cent more area than a copper one.



Courtesy Westinghouse Electric Corporation

Aluminum-wound class-B-insulated dry-type transformer, rated 500 kva, 3 phase, 60 cycles, 2,400 volts delta to 480 volts delta

An aluminum-wound dry-type transformer has from 7 to 10 per cent more iron, and its windings weigh from 50 to 58 per cent as much as in a standard copper-wound design. The over-all weight is decreased from 2 to 5 per cent. The height of the aluminum-wound unit is about 10 per cent greater. This applies to transformers meeting the same loss and impedance standards.

This application of aluminum is helping to relieve the use of copper during the critical defense build-up period and shows promise of being an economical application for aluminum conductors.

The trend to 3-phase transformers has continued into the distribution sizes. In order to cut their dimensions, arrangements of cores either new or very similar to those used many years ago have been introduced.

There has been a trend to the use of lower insulation levels and increased use of oriented steel to reduce weights and dimensions and increase ratings. For example, a 190,000-kva unit is under construction. Several units for 825-kva basic insulation level were built and there is considerable use of forced oil cooling.

TRANSMISSION AND DISTRIBUTION

A wide diversity of studies and developments in transmission and distribution were made during 1952. Higher voltage systems of considerable extent are under construction and others are being planned in the United States, Canada, and Europe in the range from 300 to 400 kv. A report of outages on 33,796 miles of line above 100 kv representing 236,666 mile-years shows that lightning still is the chief cause of outages but that these outages may be greatly reduced in importance by high-speed reclosing.

The studies of lightning phenomena were further extended to include the characteristics of extra-high-voltage transmission and modern methods for the analysis of insulation co-ordination. Study of radio interference of higher voltage lines provides further knowledge in regard to this important problem.

Experience and methods for coping with sleet formation on high voltage circuits were exchanged and analyzed by several operating companies.

Improvements in the methods of analyzing system performance including stability and improvements in a-c network analyzer components and devices bear out the continual progress in this important field of power system analysis. Guides for short-time 60-cycle overvoltage operation of power capacitors were formulated as a basis for standardization.

Economy loading of power systems has advanced both theoretically and in its practical application for improving the economy of large interconnected transmission systems.

The economics of higher voltage distribution circuits was given considerable attention during the past year. Analyses of transient fault current and recovery voltage characteristics of distribution circuits were completed which provide a basis for application and co-ordination of distribution-system protective devices.

Progress can be expected to continue on all fronts with

Courtesy Allis-Chalmers Manufacturing Company

Transformer using insulation with increased impulse strength above conventional values

the very considerable expansion of transmission systems at all voltage levels now taking place.

Science and Electronics

COMPUTING DEVICES

During the year completion of three large-scale digital computers using electrostatic storage was announced by their respective research groups. These machines, capable of performing several thousand operations a second, are a notable contribution to our scientific research facilities. Another large-scale electronic calculator, making extensive use of mercury delay line storage and noteworthy for the inclusion of checking features in its arithmetic unit and controls, passed its acceptance tests and was delivered to its user.

The year was marked by the announcement of the availability of several small general-purpose calculators whose design is based on full use of a magnetic drum both for memory storage and working storage in the arithmetic element and having a speed of from 30 to 100 operations a second. These machines exhibit a reduction in the number of vacuum-tube components and increased use of germanium diodes both for logic and switching elements of the machines.

Further progress was made during the year in the development of new components for use in digital computers. A special cathode-ray tube for use in the regenerative type of electrostatic storage was developed. Methods of using magnetic cores for both data storage and switching operations were worked out experimentally. Announcement was made of a method of storing data in ferroelectric materials by the applications of electric voltage analogous to the charging of a capacitor, but capable of holding the information for periods of weeks. Electrical delays were used more widely in computer designs and various substitutes for the conventional triggers or flip-flops were developed. During the year a small binary multiplier using transistors was built and demonstrated.

Devices for introducing information into high-speed digital computers and recording the results of computation received considerable attention, and higher speed devices for such input and output were developed. A number of printers, printing from 100 to many hundred lines a minute, were experimentally developed to take the place of teleprinters and electric typewriters.

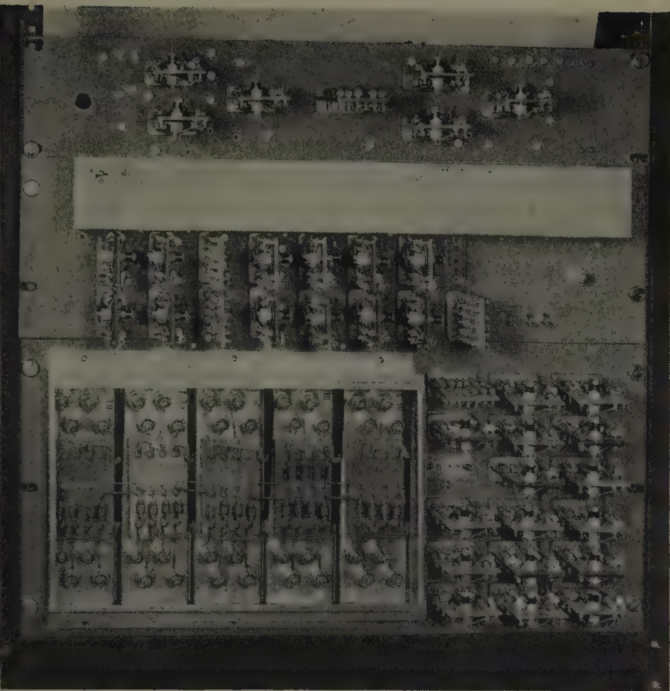
Commercial as well as computing applications of these machines were under intensive study during the year and one or two computer projects were directed specifically toward information-handling problems including air-line reservation recording, department store inventory, and maintenance of magazine subscription records. Improvements were made in the data-handling devices for use in connection with recording, summarizing, and billing telephone toll calls.

In the analogue computer field, electronic integrating and differentiating devices and associated equipment were used more widely and more freely in building analogues for specific engineering problems. In particular, two different organizations designed and built analogue computing devices for the design of small electric motors in accordance with users' specifications.

ELECTRICAL TECHNIQUES IN MEDICINE AND BIOLOGY

Apparatus for the intensification of X-ray fluoroscopic images has become commercially available during the past year. The heart of this device is a tube about 17 inches long which converts X rays into light and light into photoelectrons. The photoelectrons are then accelerated and focused to produce a brighter image with greater contrast than conventional fluoroscopic images. The

View of the electronic computer at the Institute for Advanced Study. This original electrostatic machine has served as the prototype for similar computers. The machine was put in operation last year after 6 years of developmental work



Courtesy Bell Telephone Laboratories, Inc.

A transistor binary multiplier, mounted on a 19-inch relay rack, is part of an all-transistor-and-crystal-diode digital computer. This multiplier obtains the product of two 16-digit binary numbers in 270 microseconds. A significant feature is the low power dissipation of less than 5 watts

brightness amplification is of the order of 200 or more, and this permits the use of the device with much less dark adaptation than has been required. The apparatus is a culmination of approximately 10 years of reseasch and clinical tests.

The correlation of dose measurements and energy absorption, in relation to the absorption of X rays and gamma rays in tissue, is an extremely difficult problem. An important advance in this field, by physicists at the University of Illinois, has been the measurement of energy flux of 22 mega-electron-volt X rays by means of apparatus in which the important component is the thermistor. In the field of radiology also there are new clinical methods for rotation therapy in which either the tube or the patient is moved during exposure in order to achieve more effective absorption of X rays. Finally, radiologists, veterinarians, dentists, industrial users of X rays, and physicists have become increasingly cognizant of the dangers from radiation and have reconsidered the problems of protection.

Throughout the field of medicine new and improved devices have been developed for precise measurement and for recording. These include investigations of the absorption of energy in tissue from ultrasonic and electromagnetic sources; miniature pressure-sensitive devices and temperature-sensitive devices for introduction into the body; special pumps and cognate devices which act as substitutes for organs of the body such as the heart during surgical procedures; greatly improved scintillation counters; and particularly new and improved automatic servomechanical devices for medical procedures.

ELECTRONIC POWER CONVERTERS

The trend towards greater power concentrations in electrochemical plants is continuing. While this has not produced revolutionary developments in conversion equipment during 1952, it has required the continued study and gradual developments in equipment, in the methods of protection, switching, and high-voltage power supplies.

Early in 1953 a new ignitron installation will start supplying 125,000 amperes at 800 volts to an aluminum pot line.

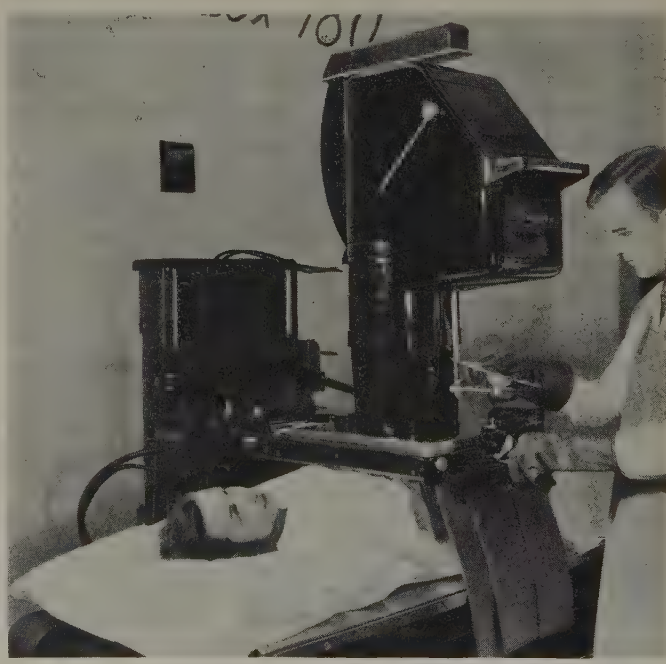
Also in 1953, two mechanical rectifier installations will be put in operation to supply 40,000 amperes at 400 volts and at 365 volts, respectively, to chlorine cells.

Two 6,000-horsepower double-cab freight locomotives utilizing ignitron rectifiers have been in service over a year.

INSTRUMENTS AND MEASUREMENTS

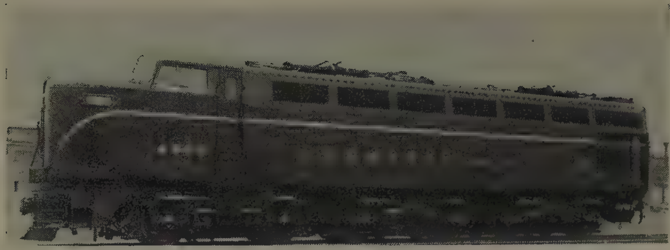
Developments in the field of instruments and measurements have continued both in the field of new methods and new apparatus as well as in the refinement of the older techniques. Due to the increasing use of 3-wire metering of domestic loads, a detailed analysis of the fundamental accuracy of single-phase 3-wire metering was made. The analysis shows the fundamental correctness of the 3-wire meter, along with methods for calculating the residual errors which may exist and whereby the probable error turns out to be negligible in terms of expected meter accuracy.

With the increasing use of the chopper for converting a d-c signal into alternating current for amplification in null detection potentiometers and control gear, it is interesting to note the development of a type where the natural period of the vibrating reed is many times its driven frequency. Thus, instead of being driven in



Courtesy Westinghouse Electric Corporation

Fluoroscopic image amplifier with which the radiologist can see more detail, work more quickly, and requires less dark adaptation



Courtesy Westinghouse Electric Corporation

Ignitron locomotive, an 11,000-volt 25-cycle a-c 3,000-horsepower unit of a 6,000-horsepower locomotive

resonance, it is driven by forced reaction far below its natural frequency and follows the driving force more exactly and with less change in characteristics.

A new strip chart recorder known as the Dynamaster has been developed which can be used with the Metameter system of telemetering. The unit records on a $12^1/_4$-inch-wide chart with a variety of speeds available between 1 inch per hour and 120 inches per minute.

In the general field of instrumentation, a great deal of attention is being paid to various types of transducers whereby a pressure, a vibration, or some other physical phenomenon, is converted into a suitable electric impulse for direct indication or recording, or for transmission through a variety of media to a distant location for indication, recording, or for control purposes.

Many of the new transducers operate by varying a resistance in either a series or a potentiometer network. A new pressure gauge has been developed incorporating a calibrated spring between the pressure-sensitive element and the potentiometer mechanism. The spacing of the turns of the potentiometer winding of over 1,000 to the inch render the surface well suited to use with a continuously moving slider.

Barium titanate pickups are widely employed and Johns Hopkins University, along with several other organizations, recently has developed units with improved characteristics including better frequency response. Johns Hopkins University also has developed a technique for vibration record analysis using a system of filters.

Supplementing other telemetering methods, an installation for point-to-point telemetering has been made using teletype transmission for the several measured variables to be transmitted. With emphasis placed on reliability, sturdiness, and simplicity rather than on high speed and excessive sensitivity, the system is in satisfactory operation over distances up to 1,000 miles for the summarizing of operational information from a group of pipeline pump stations. Using completely standard receiving teletype machines and the standard teletype transmission system, the information is placed on the line in the form of a succession of letters; the number of impressions of a single letter is the magnitude of the quantity represented by that letter.

A frequency-impulse telemetering system has been announced operating in the range of 15 to 35 cycles per second. The system converts a millivolt value into a frequency for transmission on a microwave radio link, by power-line carrier or as an audio tone on a pilot line. At the receiving end, the frequency is reconverted into a millivolt value with an accuracy of one per cent.

Installations were made over the last year of an alarm, control, and indication system for unattended microwave repeater stations. The control signals are transmitted as a 1,600-cycle-per-second tone on telephone circuits which are also used for voice communication. The alarm and indication signals are transmitted with the use of eight frequencies over 1-way voice channels which connect all the stations to a control center. An ingenious stencil can be superimposed over the indicator light panel to allow a particular pattern of lights, which agrees with the nomenclature on the stencil to become visible.

In the mobile field an outstanding digital telemetering system was announced. This system is versatile in that it can transmit one channel with 400 cycles per second response, or 400 channels with 1 cycle response each, or any intermediate pairing. The air-borne installation incorporates null sensing with servo-balancing and analogue-to-digital conversion. It transmits intelligence as coded beacon responses at radar repetition rates. On the ground a microwave tracking radar receives the pulses and temporarily stores them. After checking for false information, the intelligence is printed to three significant decimal digits.

MAGNETIC AMPLIFIERS

During 1952, the magnetic amplifier advanced into a position of much broader acceptance as a control device than it had occupied in the past few years. Greatly contributing to this advance was the increase in popular understanding of saturable-core devices which in turn led to greater confidence in them as stable, reliable system control elements. Also contributing were the great strides which were made in improving the quality and uniformity of the magnetic core materials and rectifiers associated with the magnetic amplifiers. Many applications which earlier had been held back by deficiencies in those components were able to make great progress in the past year. The commercial availability of uniform ultrathin (0.000125-inch) tape wound cores, for example, permitted rapid development and release for production of a number of magnetic-amplifier-type computer systems.

Of great engineering significance was the success achieved in the mathematical treatment of the magnetic amplifier. Through the use of compensating networks in high-performance magnetic amplifier servo systems, it has been possible to obtain lead, lag, or zero velocity error compensation. Conventional servo equations are used to determine the required gain and feedback components to give the desired changes in bandwidth and phase angle. Results obtained now in synthesizing these magnetic amplifier systems indicate accuracies commensurate with those obtained with vacuum tube systems. It has been possible to extend the bandwidth of actual systems by a factor of 10 to obtain true error-rate damping with no resulting loss in constant velocity accuracy. Through an integrating-type network, a zero velocity error system was developed in the past year, probably the first such system ever made with exclusively magnetic amplifier components.

The Manpower Shortage in Power Education

J. D. RYDER
FELLOW AIEE

This provocative article, based on data supplied by the Electrical Engineering Departments of 102 schools in the United States, indicates the quantity and quality of the graduates entering the power and electronics fields. Both causes and possible remedies for this unfortunate condition are presented here.

SINCE THE ADVENT of electronics as a major field of study, the ability of the electrical utilities and power industry to hire those whom they wished from the annual output of electrical engineering college graduates has been declining. World War II, the increasing importance of ectronics in the years since, and the unenlightened policies of some utilities, have accelerated this decline until now the position of power education in the colleges is at an all-time low, and may even be facing as extinction a major area of training.

PREDICTIONS OF POWER AND ELECTRONICS GRADUATES

THERE HAVE BEEN MANY PREDICTIONS concerning the shortage of engineering graduates during the next few years. However, these predictions rarely are broken down into the expected number of electrical engineer graduates, and never into the ratio of expected power to electronics graduates. A subcommittee of the AIEE Education Committee undertook to supply this information in 1952 as a service to both the power industry and the schools, to show the industry where it is and the schools where they may be going.

Questionnaires were circulated to 136 Engineers' Council for Professional Development accredited Electrical Engineering Departments in the United States and returns have been received from 75 per cent or from 102 schools, certainly an unusually good percentage and one which should support faith in the accuracy of the figures obtained. These departments were asked to furnish numbers of 1951–52 bachelor of science, master of science, and doctor of philosophy graduates in electrical engineering and to break them down into "Power," "Electronics," and "Other" groups. Almost no returns were received in the "Other" classification so that it may be dropped from further consideration. Some schools reported no curriculum options or breakdown of students into the two major areas, and their returns represented about one-fourth of all graduates reported. The raw data from the returns on bachelor's degrees are given in Table I.

It seems logical to assume that while some schools do not classify their bachelor of science graduates into power or electronics options, yet the actual interest of their students did not differ percentagewise from those of students in schools who did indicate such options.

It is interesting to note that the 102 reporting schools, representing 75 per cent of all accredited electrical engineering schools, in 1950–51 also granted 75 per cent of all engineering bachelor of science degrees. If the raw data of Table I are then extrapolated, on the assumption that these schools maintained their relative positions in the 1951–52 graduating class, and under the assumption of the preceding paragraph, it becomes possible to determine that 5,930 bachelor of science degrees were granted in 1951–52 of which 36 per cent or 2,130 were in Power, and 64 per cent or 3,800 were in Electronics. It is known that there were 6,700 senior electrical engineering students in residence in October 1951, and an attrition figure of 10 per cent seems reasonable, thus a check is obtained on the total number of graduates.

However, these men were not all immediately available to industry. Armed Service commitments through Reserve Officer Training Corps (ROTC) existed for 9 per cent, and it is predicted that the ROTC commitments will take $22^1/_2$ per cent of the class in 1952–53, 45 per cent in 1953–54, and 55 per cent in 1954–55. Use of American Society for Engineering Education predictions for total numbers of graduating engineers, the fact that 20 per cent of all gradu-

Table I. Electrical Engineering Bachelor of Science Degrees Granted by 102 Reporting Schools, 1951–52

Power	Electronics	No Option	Total
1,192	2,041	1,212	4,445

Table II. Anticipated Electrical Engineering Bachelor's Degree Graduates Available to Industry

Year	Expected All-Engineering Graduates	Total Electrical Engineering Bachelor Degrees	Electrical Engineers Available After ROTC Commitments	Electrical Engineering B.S. Available: Power	Electrical Engineering B.S. Available: Electronics
1952	30,000	5,930	5,400	1,940	3,460
1953	20,000	4,000	3,100	1,100	2,000
1954	16,000	3,200	1,760	630	1,130
1955	18,000	3,600	1,620	580	1,040

Revised text of a conference paper recommended for publication by the AIEE Committee on Education and presented at the AIEE Fall General Meeting, New Orleans, La., October 13–17, 1952.

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ating engineers are electrical engineers on a national and long-time basis, the percentage breakdown obtained by the questionnaires between power and electronics, and allowing for ROTC losses to the profession, makes it possible to set up the prediction data given in Table II, for the power and electronics industries.

It is customary for utility engineers to react to the indicated inroads of the electronics industry by stating that all those electronic graduates will ultimately starve economically, and thus can be considered as eventually available to the power industry. This is not a well-considered reaction. In the first place, good engineers will never starve in any field, so that good men are not likely to become available. Secondly, students undertake electronics studies because they wish to work in electronics. These men will have been well screened by the electronic industries, and most good men induced to work therein. The chances of selection of a high-quality man by the utilities are therefore much reduced.

SCHOLARSHIP IN POWER EDUCATION

CERTAIN DATA taken on the limited basis of two universities indicate the truth of the foregoing statements as to the quality of graduates available to the power industry. Discussion of these data with department heads and staff members of many other schools has shown the facts to be essentially correct on a much broader base.

Scholastic surveys were made of the graduating classes in electrical engineering for 1950–51 and 1951–52 at the University of Illinois, and for 1950–51 at another large midwestern school as a control. Quartile rankings of these graduates, as divided between power and electronics, given in Table III, are indeed interesting. In each case the scholastic distribution is skewed such that there are proportionally more power students in the lowest quartile. It might be added that preliminary data on the 1952–53 class indicate an even more pronounced maldistribution.

A reason for this distribution is readily found. At the time in the curriculum when a student is called upon to choose his option or field of work, he undoubtedly talks to more-advanced students. The word often comes back that the electronics option courses are difficult and the poorer students, who had thought of taking electronics, decide not to take the chance and instead gravitate into power work. An additional factor is that exceptional students are attracted into the electronics field by the well-publicized theoretical and mathematical features of the work. Thus the scholastic distribution is skewed at both ends.

A further investigation was made of the students in the two 1950–51 classes given in Table III. A check was made of the scholastic averages of all men who, upon graduation, were known to have been hired by companies in the radio and electronics business, and by electrical or other public utilities. Large equipment manufacturers were excluded since their work transcends both fields. On a basis of scholastic point average (A = 4, B = 3, C = 2, D = 1, failure = 0) the results are given in Table IV.

Table III. Scholastic Ranking of Electrical Engineering Graduates—Two Schools

	University of Illinois 1950–51		X University 1950–51		University of Illinois 1951–52	
Quartile	Power	Electronics	Power	Electronics	Power	Electronics
1	10	34	28	37	4	22
2	9	35	29	36	10	16
3	15	29	32	33	8	18
4	20	24	36	29	11	15

Table IV. Scholastic Average of Graduates Hired by Utilities and Electronics Companies, 1950–51

(On Basis A = 4)	University of Illinois	X University
Men hired by electronic manufacturers	2.78	2.83
Scholastic average of class	2.76	2.63
Men hired by utilities	2.62	2.53

It is apparent that the utilities are not hiring men of even average ability.

SUCCESS OF UTILITY COLLEGE INTERVIEWERS

THE UTILITIES should be interested in the success of their college interviewing practices and the return on money spent on such practices. During the 1951–52 hiring year the University of Illinois entertained a total of 391 company visits to interview graduating engineering students. Nineteen such visits were by utilities, 19 by strictly electronics and radio companies, and 6 by equipment manufacturers (two each by 3 companies.) A comparison of numbers of students interviewed by each of these company groups appears in Table V. Upon considering that each such visit entails one day or more of the interviewer's time, it can be seen that the probable return to the utilities is questionable.

Table V. Electrical Engineering Students Interviewed Per Company Visit, 1951–52

	Number of Visits	Electrical Engineering Students Interviewed	Students Interviewed Per Visit
Equipment manufacturers	6	167	28.0
Electronics-communication	19	360	19.0
Utilities	19	67	3.5

GRADUATE DEGREES

TO COMPLETE THE PICTURE of the division of the field the data obtained on graduate degrees should be presented. These data can be given only on the basis of the 102 schools reporting, since graduate degrees cannot be safely extrapolated because of extreme variations from school to school and year to year. Table VI shows the distribution of such degrees.

Experience indicates that of the number of advanced degrees shown in power, many of these students actually have interests and training in fields such as automatic control, servomechanisms, and magnetic amplifiers, all

Table VI. **Electrical Engineering Graduate Degrees Reported by 102 Schools, 1951–52**

	Master of Science	Doctor of Philosophy
Electronics	438	71
Power	134	13
Total	572	84

Table VII. **Beginning Salaries, Electrical Engineering Graduates, 1951–52**

	Per Month	
	Low	High
Electronics companies	$325	$375
Large equipment manufacturers	315	345
Public utilities	295	328

areas of little interest to the utilities. This is borne out by a survey of 20 graduates applying for AIEE Fortescue Fellowships last year, and listing proposed areas of work. Of the 20 men, 10 were interested in electronic subjects, 8 in control theory or servomechanisms, one in synchronous machines, and one in relaying.

Since the utilities have in the past been little interested in graduates with advanced degrees, these data are only of academic value. Whether this policy of disregard of graduate work is a wise one is not a subject pertinent to this discussion, although it has certainly led directly to the present shortage of stimulating and proficient teachers of power subjects.

STARTING SALARIES

A REMAINING ITEM to be discussed is that of the beginning salary for the new graduate. Here the utilities have lagged far behind as is shown by representative salary ranges for various fields for the 1951–52 recruiting year as presented in Table VII. The utility figures in this table are from the *Bulletin* of the Edison Electric Institute for July 1952, and the other data are believed fairly representative of the situation. This article also gave $342 per month as an average utility salary after 2 years' service with the company. In 2 years with a utility a man can thus be earning as much as his average starting rate might be in the electronics field.

SOME REMEDIES FOR THE SITUATION

THE CURE or remedy for the situation is in the power industries' hands, since the schools cannot greatly influence the interests of their students. Wishful thinking such as "the electronic industry cannot supply jobs to all those graduates and in a year or two everything will be normal again" is worthless and unfounded. The electronics industry does and can supply those positions because the electronics industry is not bounded but expanding. A dynamic $9,000,000,000 a year business is not suddenly going to fade away.

The utilities should raise their salary scales to attract better men, and they should underwrite scholarships in the universities. They must alter their training policies and give the new employee responsibility at a rate far beyond that of the past. In fact "training courses" and "apprenticeships" should be abolished and replaced with an "acquaintanceship period." A man who has just completed 4 or 5 years of difficult university training does not take kindly to another year or two in training at work where the technical level is much below his abilities.

One reason for the glamour of electronics is that a complete system may be assembled and operated on a laboratory table, thus satisfying the creative urge of the designer. Calculation of conductor sizes or substation loadings for equipment he may never see does not satisfy this urge for the young utility engineer. He should be very quickly placed, even if only for a few months, in the planning group or the group making network analyzer studies, so that he can see how his and other contributions fit into the over-all systems.

CONCLUSION

NOTHING in this article should be construed as implying that the utility and power industries do not have opportunities or stimulating problems for young engineers. The situation is fully appreciated by practically all teachers, but not by the industry interviewers sent to the colleges. The utilities must do a selling job, but they must sell growth of a young man's responsibilities, not growth of the system in kilowatt-hours. To a young graduate, security is not a synonym for salary.

It should also be understood that while students are here classified as "power" or "electronics," their training is not usually so narrow as to limit them, and transitions are possible and are made. The difficulty of transition lies in the state of mind of the student and not with his training.

To summarize, it seems desirable to quote from two of a number of letters received from electrical engineering department heads when they returned the Education Committee questionnaires. From the head of the electrical engineering department of one of our large eastern schools, the following was received: "The power companies seem unable to convince the students that they are interested in creative, aggressive engineering. Their training programs are not in tune with the times. The opportunities for professional advancement in other industries are so much greater that only second-rate graduates can be hired by the power companies. In my opinion the companies are steadily running themselves into the ground by failing to attract young men of high intellectual capacity to the profession."

From another department head of a midwestern university, "Of the 90 who received bachelor of science degrees in 1951–52, I know of only one who went with a power company. One seems forced to conclude that under present-day circumstances a young man with training in the power field is as much in demand as one with training in electronics, but not by the power utilities."

It is hoped that the electrical utilities do desire to employ good men and will be active in improving their standing among student engineers. If nothing is done then many schools probably soon will be forced to cease offering a heavily emphasized power program.

Student Branches of the AIEE

D. D. EWING
FELLOW AIEE

The great increase in the number of AIEE Student Branches during the past 50 years naturally has brought about an increase in the problems involved, problems of leadership and attendance, of funds and programs. The Institute is very much interested in the development of student activities, however, particularly as the Branches constitute our largest single source of new members.

THE STUDENT branches of the Institute and their activities have today reached the point where they constitute a serious subject for consideration. Fifty years ago, there were some 15 Branches. As of May 1, 1952, there were 132 Student Branches of the AIEE with a total membership of 8,857. As these Branches are located at various universities, and as universities are all somewhat different, naturally the problems involved in the different Branches differ also. Before discussing this subject however, it might be well to present a brief description of the background and aims of the AIEE.

INSTITUTE BACKGROUND

THE INSTITUTE was founded in 1884 by a group of men who at that time called themselves electricians. On the list of founders were such famous names as Alexander Graham Bell, Thomas A. Edison, Elihu Thomson, and Edward Weston. The organizational meeting was held on May 13, 1884, and there were 71 charter members. A speech by Dr. Rowland of Johns Hopkins University before a national conference of electricians that year may have been partly responsible for the keen interest in the original development of the AIEE. Dr. Rowland said: "Let physical laboratories arise—let technical schools be founded—it is not telegraph operators but electrical engineers that the future demands."

The major electrical work of those days was, of course, in the field of telegraphy.

What is the situation now? The AIEE had as of May 1, in addition to the 8,857 Student members previously noted, 42,220 members including 6 Honorary Members, 1,512 Fellows, 10,314 Members, 30,313 Associate Members, and 75 Affiliate Members. This adds up to a total membership of 51,077, and a considerable number of new members have been elected since.

The work of the Institute now involves an operating budget of approximately $1,000,000 a year and is carried on through the activities of 96 Sections, 50 Subsections, and the 132 Student Branches. The volume of published material is large; during 1951, 3,383 pages of technical material were published. For operating purposes, North America is divided into ten geographical Districts, all of which lie within continental United States except for a portion of District 7 which is in Mexico and of District 10 which is in Canada. Each of the Districts is presided over by a vice-president, and in the governing organization, in addition to these ten vice-presidents, there are twelve directors, the two most recent past presidents, the treasurer, the secretary, and, heading the whole organization, the president. Each of the Sections, Subsections, and Branches has its appropriate officers. The AIEE is a large organization and one of the most democratic professional technical organizations in existence. The technical and administrative work of the organization is handled by approximately 300 committees with more than 5,000 members. Not included in this total are the committees found in the geographical Districts, Sections, Subsections, and Branches.

The Institute was not always so subdivided. For a number of years its activities were all centered in New York City and no meetings were held elsewhere. Before 1900 the matter of District organizations had been discussed more or less casually but nothing much was done about it. Dr. Charles F. Scott, president of the Institute in 1902–03, wrote a very interesting set of reminiscences relative to electrical engineering in general, and the AIEE in particular, for the 50th anniversary issue of *Electrical Engineering*, which was published in May 1934.[1] In a discussion of the AIEE, Dr. Scott said that his predecessor, the General Electric Company's famed Charles P. Steinmetz, had set such a high standard of performance that he was a bit at loss as to what to do to keep up the standard. What he did do is indicated by the following abstracts from his article:

> When president-elect, I asked T. C. Martin what the Institute ought to be and to do. He was a past president, editor of *Electrical World*, and as a special agent of the United States Census was just completing the first census report on the electrical industry (1902). He said "I don't know what the electrical industry is going to be in the future, but in the past it has been doubling every 5 years." I was stunned; how could we use twice as much electric power, and so soon! The original Niagara Falls powerhouses were being completed, the elevated railway in New York was electrified, the subway was soon to start, the public utilities were putting in big generators; but if the curve were to continue up, where were the men to come from to operate the accelerating industry—men competent to meet the exacting and increasing responsibilities of electric

Revised text of an address, "Student Branches and Their Activities," presented at the Student Activities Committee Banquet held at the University of Toledo, Toledo, Ohio, October 31, 1952.

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service—more men, better men. I had taken it for granted that the Institute was to promote the arts and sciences related to the utilization of electricity by adding to knowledge through papers, by their discussion and publication. Here was a new need—men. Should not the Institute develop men as well as ideas? I had been interested in the training of college graduates for one company. Here was a universal need for better graduates. The future men of the industry were in the colleges being trained in theory. Why should not the Institute give them an insight into the problems and practices of the profession, without waiting for a sudden plunge from theory to practice on graduation? So I asked several of my professor friends; they agreed; Professor Ryan at Cornell wrote (condensed) "Bully idea; we've already started."

At another point in the article, in a discussion of how Sections and Branches started, he said:

The committee on local organizations among members and among students had as chairman Calvin W. Rice. He undertook to prepare a statement with rules for organization and procedure; but he didn't have it ready, so I undertook to show him how on the evening before copy for the October announcement had to be ready. Until midnight we simply devised questions without getting answers. What should be the Institute regulations and the local bylaws? What headquarters supervision and what the local authority? Should Institute papers be presented locally or should there be local papers, and what should be their status? Finances—should there be dues? Every situation that we thought of ended in an interrogation mark. The student enterprise was even more difficult to precrystallize. One alternative was to take months to make bylaws; the other was to start. So we asked members to get together in various places and start meetings, we asked professors to have student meetings; and they did. Years later the experiences gained were a basis for bylaws. We did not know then what I discovered very recently that two pages of fine print rules for local meetings had been established many years earlier, and it was lucky we didn't for active effort to meet varying conditions is better than passive compliance with preconceived and restrictive rules.

The first quotation was concerned with what we today call Student Branches; the second with Sections, although they too were called Branches in those days. By May 1904, there were 15 recognized Student Branches scattered over the country.

The objectives of the Institute as set forth in the Constitution are: "Its object shall be the advancement of the theory and practice of Electrical Engineering and of the allied Arts and Sciences and the maintenance of a high professional standing among its members." Naturally the objectives of the Student Branch should be of a similar nature. To students who question the value of AIEE Student membership, one might give the following answer:

Why should you join the AIEE? Just to have your name in the Year Book along with the 42,220 other members of this great organization? That is an important reason but not the most significant one. It is an important reason because it places your name, your company affiliation, the nature of your work, and your address in a permanent record—a record much used by those who are looking for men with special skills and special knowledge or for possible committee members, or possible collaborators in a given field of electrical engineering. The AIEE is the largest engineering organization in the world, and it is decidedly worth while to have your name in its Year Book. As a student, of course, you will not be listed, but by becoming a Student member you will have made the proper start toward eventual inclusion when you have reached the status of Associate Member.

The really important reason, however, is the opportunity for professional growth that the Institute affords the engineer. Each year Section, District, and national general meetings provide forums at which hundreds of papers dealing with the latest developments in electrical engineering are presented and discussed. At these meetings you can keep up to date in knowledge, meet fellow members of your profession, discuss problems of mutual interest, and broaden your professional acquaintanceship with other electrical engineers and with your very profession itself.

Student Branches of the Institute afford opportunities for a considerable amount of independent activity and initiative on the part of students for cultivating those qualities needed by the engineer but not usually acquired in the classroom. These qualities may be developed through the technical, social, and literary activities of Branch work.

Only a small annual fee is required of students and one of the tangible things which they receive in return is the monthly magazine, *Electrical Engineering*. This magazine contains many pages in each issue devoted to technical articles in easily readable form, as well as the current news of the profession. Another tangible return is the remission of entrance fees when the Student member makes application for the next higher grade of membership.

All of the Branch Counselors and student officers receive regularly each year published information relative to Student Branches and their activities, and undoubtedly all of the older professional engineers in the organization are greatly interested in the development of student activities. The Board of Directors has set up a national committee dealing with Student Branches and the Board devotes considerable time to discussing Student Branch matters. Nearly half of the session time at the meeting of the Board in June in Minneapolis, Minn., was given to this subject, and it was discussed again at the Phoenix, Ariz., meeting in August 1952. As a result, the following action was taken by the Board at the Phoenix meeting:

VOTED that the action of the Board of Directors, on June 26, establishing a new plan for Student Branch appropriations, be interpreted as providing that the number of Student members in each Branch be those in good standing on November 1 plus the number of applications, accompanied by fees, on file at AIEE headquarters as of November 1; that one-half of the $1 per member portion be sent as soon as practicable after November 1, and the

second half be sent by February 15; and that a student whose application and fee have been received at head quarters be eligible for prize competition.

You will note that this action provides "sinews of war" for the Student Branches. It should incite Student Branch officers and their Counselors to put on vigorous membership campaigns which should enroll a larger number of students earlier in the school year. You will note also that it gives a definition for the officially enrolled student, a definition which previously had been lacking. The Board of Directors, the vice-presidents, and other District officers have the welfare of each Student Branch very much in mind. There is possibly a selfish reason in this because the Associate Member, the Member, and the Fellow of tomorrow is today in some one of the Student Branches in the country. These Branches are the largest single source of new members.

UNIVERSITY BACKGROUND

Even before there were Student Branches many of the schools and departments of electrical engineering in the colleges and universities of the country already had organized groups or electrical engineering societies of a local character. When the Institute made it possible for these societies to become an integral part of the Institute, the reaction of the electrical engineering faculties was enthusiastically favorable and it has always remained thus. However, the problems involved in Branch operation are very different in 1952 than they were in 1902.

In 1902 automobiles were few and far between and were the playthings of the rich. There were no good roads. Moving picture shows were confined to the old-time nickelodians where the quality of the pictures was so poor that one could not gaze at them long without severe eye strain. There was no television, no radio; even the newspapers, except in metropolitan areas and larger cities, were published biweekly or on a twice-a-week basis. University athletics were not in the big business class as they are now. Fraternities and similar organizations were not common on the campuses, and so the students had time to spend on such work as was involved in the operation and planning of Institute Branch programs. The conditions of today are very different and the number of extracurricular activities has grown so greatly that students do not find enough time to spend the amount of work on their class exercises that they should. Branch work today has many competitors and attendance constitutes one of the major Branch problems.

Obviously, Branch problems involve both the Branch Counselor and his associates on the faculty, the Branch officials, and the Branch Student membership. The counselors have to be advisers and diplomats. It is also obvious that the proper men should be elected to the official positions in the Branch. Unfortunately, the student can elect a popular student to many offices. The man who is a good Branch chairman or president is possibly also good material for the presidency of Tau Beta Pi, Eta Kappa Nu, his social fraternity, or for a similar position in a residence hall. Possibly also he may be proper material for the editorship of a student daily paper or a student engineering paper. Certainly he cannot do all of these things and at the same time successfully carry on his class work as a student. Many universities, of course, have regulations limiting the number of student activities in which a student may be engaged at any one time. One of the problems of a Branch Counselor is diplomatically to discuss election matters with students and thus at least attempt to secure the election of properly qualified students and those who are not overloaded with other activities; that is, to secure proper spreading of the work among qualified students. This whole problem, of course, involves student politics, and like politics everywhere, the matter must be handled with great diplomacy.

However, once a group of officials is elected, then the sponsor has the problem of trying to inspire these young men and to build up their enthusiasm for Branch work, and for Institute work in general. Here he must exercise his talents as a real teacher, and he should be thoroughly familiar with Institute regulations pertaining to Student Branches. He must be a source of inspiration when it comes to such matters as program arrangement and even program scheduling. In most colleges and universities there are many activities in which such organizations as AIEE Branches may engage, and many of these activities concern the everyday life of a campus community. In the past the funds available from the Institute headquarters have been so small that Branch officials and members have been prone to set up money-making activities very much like those of women's church organizations. Some of these activities certainly have not been professionally worth while, and the recent action of the Board of Directors in providing a greater allowance for Branch activities should be very helpful in this respect.

One of the major problems of a faculty sponsor is the ever-changing personnel of student officials and members. The Branch very closely follows the classes. Each year the sponsor must start in with a new group and guide them along the proper pathway of knowledge and efficiency.

If a Branch faculty Counselor has his problems, so also do the Branch student officers. The Institute regulations are very democratic as far as these officials are concerned and the Branches can have as many officers or as few as they wish. Usually there is a chairman, a secretary, who also possibly doubles as a treasurer, and a program committee chairman. Often there are a number of other members of the officialdom of the Branch. All of these people have some new things to learn. Usually, the chairman and other top officials have started in their earlier years in college as minor officials and already know something about Branch operations; but when elected to a new job they must learn the requirements of that position. Of course, it is up to the Branch officers to build up student enthusiasm. In some areas of work this is fairly easy. In other areas it is not. In any case, there are certain fields which for a time have an aura of glamour. Currently the most glamorous fields seem to be television, servomechanisms, and computors, closely followed by radar and industrial electronics.

Another student problem is that of programs. For best results it would seem that the programs should be

given by the students themselves, but there is also the desirability of having certain programs presented by outside speakers. Also, first-class motion pictures of industrial operations are desirable. Not the least of the trouble of some of the Branches is that of selecting a proper meeting place. Generally it is possible for Student Branch meetings to be held in the electrical engineering building or other quarters occupied by the school or department of electrical engineering. However, in some cases there are certain difficulties in the way of finding desirable meeting places or facilities where lantern slides or motion picture facilities are available, or possibly where a demonstration lecture can be made part of the program.

Another problem for the students is that of living up to AIEE regulations relative to Branches and at the same time living up to campus regulations relative to student organizations. On some campuses there is a tendency to observe a fairly strict control over student operations of any kind particularly where out-of-town speakers or money, or both, are involved.

All of these problems must be familiar to the Counselors and student officers of our Branches; or possibly they are confronted with others equally as difficult. The important thing, however, is that our problems are continually being solved, as evidenced by the growth record of the AIEE Student Branches—from but 15 in 1902 to 132 just a half century later.

REFERENCE

1. The Institute's First Half Century, C. F. Scott. *Electrical Engineering*, May 1934, pages 645–70.

Electric Glass Welding

M. R. SHAW
MEMBER AIEE

A huge new area has been added to the electrical art through the extension of the electric welding process to glass. The mass market can be reached as it is unnecessary to have highly skilled personnel, and better quality results with more accurate heat control.

THE ELECTRIC welding of metal is a relatively new and rapidly growing process in the metal fabrication industries. Even newer and currently enjoying a more rapid expansion is the electric welding of glass. While there is some similarity between the techniques employed, the widely differing physical properties of the two materials make the electrical requirements quite distinct.

TYPE OF ELECTRIC HEAT USED

IT MAY BE SAID that all forms of electric heat[1–3] have been used in welding glass. Probably the most expensive type of electric energy is that in the ultrahigh-frequency portion of the spectrum. Electric energy at this frequency has the ability to produce appreciable heat in most dielectrics and has been so used on glass under certain circumstances. The harder glasses maintain their dielectric characteristics up to moderately high temperatures. It is in this region that dielectric loss methods of heating may be used as part of an electric welding process. Radio-frequency energy also may be used for magnetic induction heating of materials having fair conductivity. Since glass at very high temperature has moderate conductivity it may be heated for welding by the high-frequency induction method. Generally, however, unless the dielectric loss or induction heating method is uniquely suited for the application, other types of electric heating will be more practical. The kind of electric heating found most useful for glass welding on a production basis is the simple resistance loss accompanying the passage of current through the glass between opposed electrodes. The source of energy for this type of resistance heating may be the 60-cycle power line or, under certain circumstances, a high-frequency generator. Undoubtedly time will see the development of energy sources for dielectric and induction heating which will greatly change their economics. For the present, good use is being made of the simpler method which is the subject of the remainder of this article.

RESISTANCE HEATING IN GLASS

SINCE RESISTANCE HEATING is to be examined closely, it is appropriate that the electrical properties of glass be known. A resistivity-temperature curve for a borosilicate glass is shown in Figure 1. This graph covers the interval of room temperature to 1,500 degrees centigrade, which is approximately the same as that involved in welding this particular glass. The extreme range of resistivity is immediately evident. The resistance of a given path will decrease by a factor of 10^{14} as the temperature increases during the welding cycle from the room temperature value

Full text of paper 52-320, "Electric Glass Welding," recommended by the AIEE Committee on Electric Welding and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Middle Eastern District Meeting, Toledo, Ohio, October 28–30, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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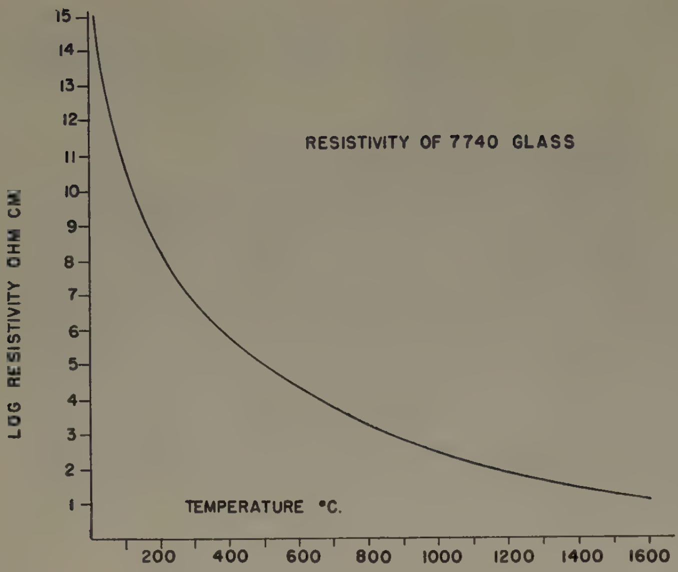

Figure 1. Resistivity-temperature characteristic of a borosilicate glass

Figure 2. Comparison of voltage and current requirements for heating metal and glass

Current and voltage for 100 watts input to one cubic centimeter

Temp	Mild Steel		Glass No. 774	
°C	volts	amperes	volts	amperes
20	5.0×10^{-2}	2.0×10^{3}	0.3×10^{9}	0.3×10^{-6}
500	7.7×10^{-2}	1.3×10^{3}	4.0×10^{3}	25×10^{-3}
1000	11.1×10^{-2}	0.9×10^{3}	200	0.5

to the fusion point. What this means in terms of amperes, volts, and power is indicated in Figure 2 where glass and metal are compared. Here the voltage and current necessary to deliver 100 watts to a particular load are tabulated for different temperatures. At 20 degrees centigrade in the case of steel the current and voltage requirements are easily within the realm of practicability. This is not so for the glass however. In this instance a voltage is required which is many times that which the normal surrounding atmosphere would support. The cube would be heated by the resulting flashover. Arc heating of glass has been employed but at less than a third of a billion volts.

The next two lines in the tabulation show the conditions prevailing at successively higher temperatures. A slight upward adjustment in voltage is necessary for the steel to compensate for its increase in resistivity. Going to the 500-degree-centigrade temperature in the case of the glass changes the situation from one that is impossible to one that is reasonable. At this temperature a borderline condition obtains. With well-designed electrodes it probably would be possible to restrict the current path to the glass. This condition, while not impossible, is still hardly practical. Going on now to 1,000 degrees centigrade it is observed that a potential of only 200 volts is required. At this point there is no question about being able to confine the current to the glass. The region between 500 and 1,000 degrees centigrade, therefore, is where it is possible to begin to employ electric resistance heating on a practical basis in this particular material.

There is no special significance about the value of 100 watts per cubic centimeter used in this example. Due to the negative resistance-temperature coefficient of glass, the electric heating process becomes self-accelerating when the power input exceeds the heat loss. This circumstance has both good and bad aspects. The favorable side is that the direction of change is such as to promote the passage of current through the load rather than through the surrounding atmosphere. The disadvantage is that a runaway condition is quickly reached and provision must be made to take care of it. In the foregoing example, the electric heating process would become self-sustaining at any combination of temperature and voltage where the power delivered was equal to the heat losses. This balance could be maintained or changed in either direction by proper adjustment of the circuit elements. Experience has shown that the integrated effect of all factors including practical limits on the voltage level and changing dielectric strength of the surrounding atmosphere is to establish a minimum temperature of about 500 degrees centigrade for starting the electric heating cycle in the harder glasses which are of most interest. The problems associated with electric glass welding are now fairly well defined. Some preheating device is necessary for bringing the glass temperature into

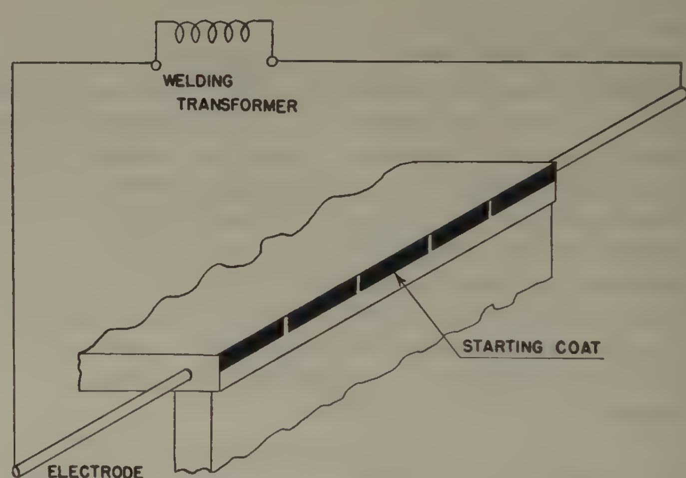

Figure 3. Application of starting coat on glass to be welded

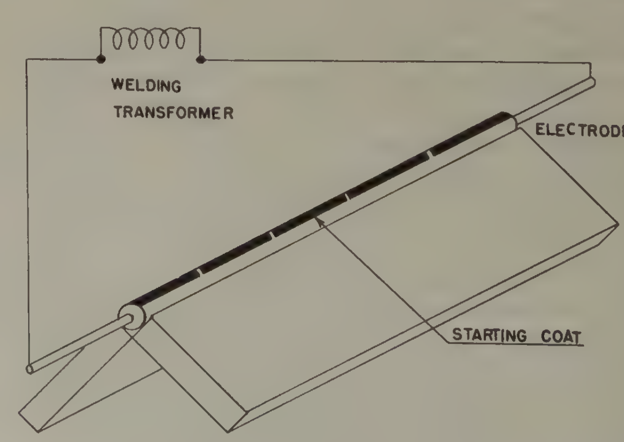

Figure 4. Application of starting coat to glass filler rod

the starting range and a method of controlling the power is required.

STARTING COAT FOR PREHEAT

SEVERAL WAYS OF PREHEATING have been developed but there are two which usually are used. One employs colloidal graphite painted on the glass to form a semiconducting stripe.[4,5] It may be painted on one of the pieces to be joined as shown in Figure 3 or painted on a third piece of glass which serves as a filler rod as shown in Figure 4. It will be noticed that in both cases there are small gaps equally spaced along the coat. These gaps play an important role in the starting mechanism. When power is applied to the electrodes at the proper voltage level, a series of small arcs form along the rod at the gaps in the coat. These arcs, when properly controlled, hug the glass welding rod very closely and as a result impart to it considerable heat. The effect of this is to raise the glass temperature with resulting decrease in resistance in the zone under the arcs. Concurrently the coating on the glass burns back from each end of the arc. These two actions, by decreasing the resistivity of the glass and stretching out the arc path, work together to bring about the transfer of the current from the surrounding atmosphere to the welding rod. Once the current is well established in the glass, the power is allowed to increase and the fusion takes place. Because of the negative resistance temperature coefficient of the material, the tendency of the current path is to increase in cross section relatively slowly. By a rapid acceleration of the power input, the filler rod can be liquified and welded to the pieces being joined before the latter are appreciably distorted. This high degree of heat localization is often an important advantage of the electric process.

The beginning and end of a 15-inch filler rod weld are shown in Figures 5 and 6. The electrodes contact the ends of the rod until immediately before the power is turned off. At this point they are swung back drawing an arc which melts out the mark which otherwise would be left at the contact spot. Figure 7 shows a group of typical sections built up by this method. The glass used in making these was 1/4 inch thick.

FLAME PREHEAT FOR STARTING

WHEN THE WELDS to be made are cylindrical in shape, a flame is often used as a preheating medium.[6] The heating of the flame is principally on the surface of the glass. Increasing the temperature of the flame to increase the heating rate serves only to promote damage of the glass surface by volatilization. However, flames of moderate intensity may be used to initiate the

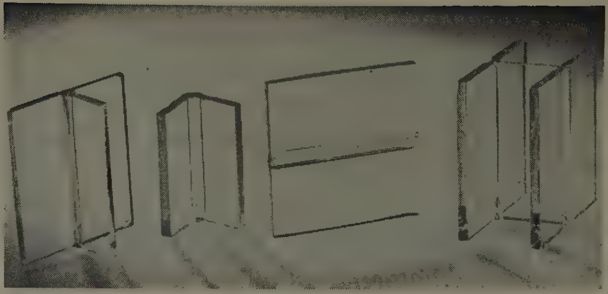

Figure 7. Typical sections made by filler rod method

electric heating process by bringing the glass temperature into the 500-degree-centigrade zone. The electric heating that follows is then volume heating thereby permitting a much faster heating rate. Once again a high degree of localization is realized and the zone initially subjected to the preheat flames receives most of the subsequent electric power.

An application where the ability to localize the heat is of great importance is in the field welding of PYREX brand glass pipe line. Flame preheat from a pair of easily manipulated oxy-hydrogen hand torches is used. Insulation is provided to permit the connection of the electric power at the flame end of the torch leaving the other end safe for the operator to hold. As an additional safety precaution, only high-frequency power is used for this

Figure 5. Beginning of 15-inch filler rod weld

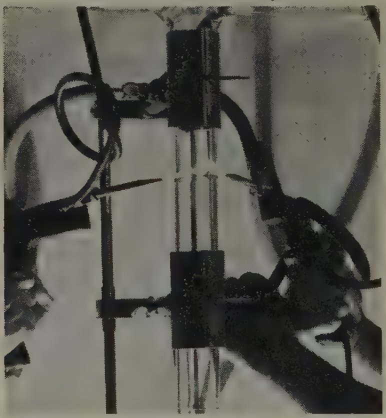

Figure 8. Field welding of PYREX brand glass pipe line

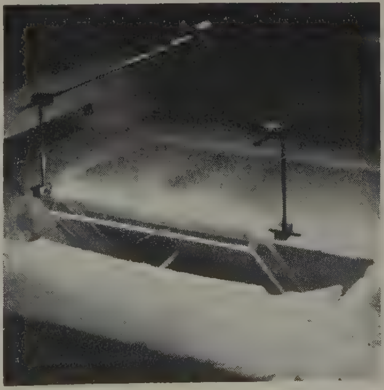

Figure 6. End of 15-inch filler rod weld

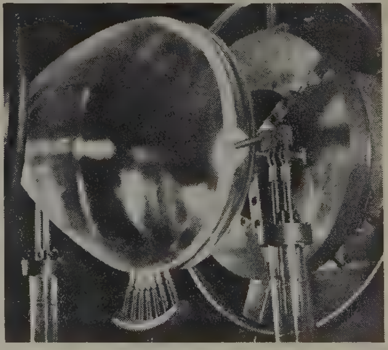

Figure 9. Electric welding of large television tube

type of welding. The operators position the ends of the pipe to be welded by means of a jig as shown in Figure 8. The two flame electrode tips are then oscillated through 180-degree arcs thereby heating the entire perimeter of the pipe. The flames serve a second purpose by forming a flexible brush to lead the electric power to the load. This is a desirable feature in the hand-manipulated process because it is not easy to maintain the electrode spacing with any accuracy. When the hot stripe is developed, the power is turned on and the ends of the pipe brought up to the fusion temperature as they are worked together. A band approximately 1/4 inch wide is all that is actually hot enough to flow. This band is supported by surface tension forces and slightly increased internal pressure while the union takes place. As a result, it is easy for an unpracticed person to maintain complete control of the glass and turn out welds beyond the capacity of even the skilled glass artisan working with flames alone. This was demonstrated in the construction of the atomic plant at Oak Ridge, Tenn., where there were at one time 25 men recruited from the ranks of the pipe fitters engaged in the installation of $7^1/_2$ miles of glass pipe line using the Corning electric glass welding system.[7]

With increasing diameter it becomes advantageous to place the parts to be welded on a lathe. The work may then be rotated in the preheat flames to assure uniformity of heating. Due to the greater size of the parts handled on the lathe, a battery of gas-oxygen flames is usually used for this purpose instead of depending on the heat from the electrode flames. Since the large work done on the lathe places greater demand on the power source, the 60-cycle supply is generally used because of its economy and greater reliability. The lathe setup for welding a large television bulb is shown in Figure 9. A substantial proportion of the television bulbs reaching the market today are made by the electric welding process.

POWER SUPPLY AND CONTROL

60-Cycle Welding. Sixty-cycle potentials as high as 20,000 volts have been required to handle some of the large jobs encountered. A distribution-type transformer is usually satisfactory as a source of high voltage and has the advantages associated with standardized components. A certain amount of circuit reactance is required to stabilize arcs in either the starting coat method or the flame electrode method. The requirements for inductive reactance for this purpose and also to provide power control are adequately satisfied by saturable core reactors in most cases. A simplified circuit diagram is given in Figure 10.

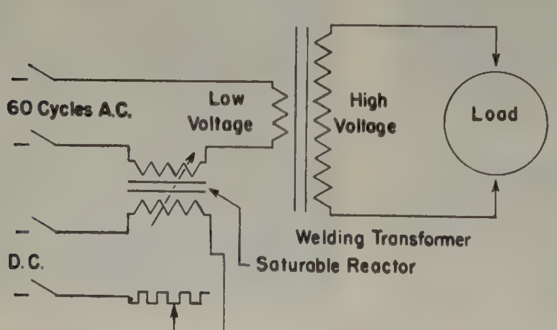

Figure 10. Basic circuit for 60-cycle glass welding

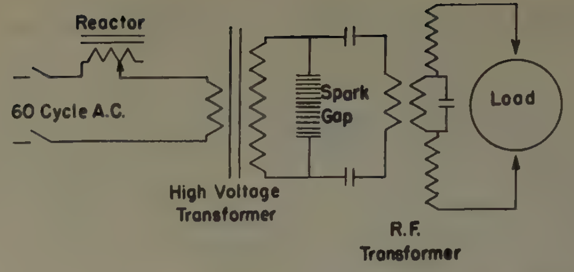

Figure 11. Basic circuit for high-frequency glass welding

High-Frequency Welding. The source of high-frequency energy most generally used for this type of welding is the spark-gap converter. The usual induction heating type of equipment is not suitable without modification because a high voltage rather than a high current output is desired. A basic circuit drawing for a suitable converter is shown in Figure 11. The frequency used is not important, something in the range of 400 kc being usual. Power control is generally an on-off arrangement but load matching circuits have been designed for delivering maximum power during the important part of the heating cycle.

SUMMARY

THE EXTENSION of the electric welding process to include glass has opened up a vast new field to the electrical art. Hundreds of kilovolt-amperes of installed capacity are now turning out highly technical products at a rate such as to permit them to reach the mass market. Electric glass welding processes have been developed for handling all kinds of joints in both straight and curved bodies. The advantages of electric glass welding may be attributed to the following factors:

1. It is possible to develop higher temperature within the body than with flames alone.
2. A faster heating rate is possible without danger of destroying the surface of the material.
3. The highly localized nature of the heat eliminates the possibility of distortion in the main body of the parts.
4. Accurate control of the heat is possible resulting in better quality of finished product.
5. The nature of the process is such that it may be carried out by relatively unskilled personnel.

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Artificial Cooling of Power Cable

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WHILE THE ARTIFICIAL COOLING of rotating machinery and transformers is a practice which is familiar to most electrical engineers, it rarely has been used in the past in cable work. However, with the growth of load and the increased congestion which has resulted therefrom in power stations, substations, and their immediate neighborhood, artificial cooling of cables has become essential in some locations and economically desirable in others.

Theoretically, heat can be removed from cables by conduction, convection, radiation, and evaporation. The last method is seldom of much practical use. It is sometimes possible to improve conduction locally, for example, by saturating the earth surrounding a buried cable with water, and to improve radiation by providing the cable with a matte black surface. It seldom is possible to use the first of these expedients over a long length of cable line, and the difficulty of maintenance in service usually rules out the second. In short, it rarely is possible to control conduction and radiation effectively by artificial means over long cable lengths or long periods of time.

Forced convection, on the other hand, is often a very practical means of solving a difficult heating problem especially if relatively short runs of cable are involved. The technique used will depend on the type of cable and the way in which it is installed. The commonest techniques now in use or under consideration are as follows:

Cables in Ducts: 1. Cooling by water pumped through loaded ducts. 2. Cooling by air blown through loaded ducts. 3. Cooling by water pumped through a pipe incorporated in the duct bank.

Cable in Tunnels (entire tunnel is cooled by forced ventilation): 1. Cable supported in free air in a tunnel. 2. Cable in ducts in a tunnel wall.

Pipe Cable: 1. Circulation of the pressure medium (oil or high-pressure nitrogen) and cooling of this medium by means of a heat exchanger. 2. Circulation of water through a small pipe installed with the cables in the cable pipe.

It is seen that there are two fundamental ways of utilizing forced convection. The first way involves direct contact between the cooling medium (circulating oil, or gas, or ventilating air) and the cable surface. The second involves the separation of the cooling medium from the cable by a barrier having a thermal resistance of its own.

In the first case the cooling medium is effective in two ways in promoting heat dissipation. First, it actually removes heat over and above what is dissipated to the earth surrounding the cable, duct bank, or cable tunnel. And second, the movement of the medium reduces the surface thermal resistance of the cable by a sort of "scrubbing" action.

In the second case there can be no scrubbing action since the cooling medium is not in contact with the cable surface; and furthermore, the effective thermal resistance between the cooling medium and the cable is increased by the thermal resistance of the barrier which adds directly to that of the cable surface. Other things being equal, cooling by direct contact is the more efficient plan.

The earth and the cooling medium act as parallel sinks and the temperature of the cable and that of the cooling medium vary along the cable length. Equations have been developed which give the temperature at any point along the cable line including the hot end, which is normally the point of greatest interest. There is one equation for the case of direct contact and one for the case where a barrier is interposed. By the use of suitable thermal constants these equations can be used effectively regardless of whether the circulating cooling medium is air, oil, or water.

Additional equations have been adapted from the work of McAdams[1] and Max Jakob[2] which show how the surface thermal resistance of the cable is reduced by the movement of the cooling medium; and an approximate method of estimating the thermal resistance of a concrete wall containing ducts has been presented.

The following conclusions have been reached. While water pumped through loaded ducts is more effective as a cooling medium than air, it is apt to be costly and difficult to handle and may possibly cause corrosion or even erosion troubles. For short lengths of duct bank air blown through the loaded ducts is to be preferred.

In ventilated tunnels the most effective cooling is obtained by supporting the cables directly in the tunnel air on racks or in widely spaced troughs. The use of ducts in the tunnel wall represents a more nearly fireproof construction but affords this additional safety factor at the cost of less efficient cooling.

Circulation of the pressure medium in a pipe cable is more effective than using cooling water passing through a small internal pipe; and oil is a more satisfactory circulating medium than high-pressure gas. This last conclusion is in sharp contrast to the condition which is obtained when the pipe cable is cooled by natural convection of the pressure medium; in this case gas is almost as effective a cooling medium as is oil.

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Digest of paper **52-152**, "Artificial Cooling of Power Cable," recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Aircraft Radio Interference Measurements

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For radio interference studies covering a wide frequency range, evaluation of the noise levels requires a great number of measurements with different instruments for each frequency range and type of communication. A high-speed oscillograph is valuable in such work as it can show the effect of each suppressive device on the undesirable transient.

IT IS ESSENTIAL to know the waveshapes and statistical distribution of impulsive interference transients for working out adequate interference reduction methods. Interference pulses such as are produced by corona and sparking phenomena in electric equipment present a serious problem in measurements. Conventional noise meters convert any kind of pulse to the same fundamental shock excitation waveshape determined by the characteristics of the initial circuits and thus the original character of pulses is masked. The noise meter is useful in assisting in the routine elimination of noise from various electric devices, for it informs the investigator of the progress made, and it indicates when the noise is of such a character that it no longer will cause appreciable disturbance in a typical receiver. However, for interference studies covering a wide frequency range, evaluation of the noise level requires a vast number of laborious measurements with different instruments for each range of frequency and type of communications. When evaluating atmospherics or other interference that changes character with time, noise meter measurements cannot be made quickly over a wide frequency range. Thus, for a fundamental study of the nature of interference, the oscillograph provides more useful information. A high-speed oscillograph is of value even in routine suppression tests, since it can show the effect of each suppressive device on the undesirable transient graphically.

TYPICAL IMPULSIVE INTERFERENCE TRANSIENTS

IMPULSIVE RADIO interference transients generally consist of steep-wavefront electric impulses which shock-excite the tuned circuits of the receiver. In the case of aircraft these pulses may be generated directly on the antenna system or may be transferred to the receiver from interfering electric equipment by coupling from the conductors of the interior electric wiring. In either case, a damped sinusoidal wave-train of sufficient duration to cause an audible disturbance at the loudspeaker is set up in the tuned circuits of the receiver by each pulse. The maximum amplitude of the oscillations will depend on the rate of voltage rise and amplitude of the interference pulse and, within limits, on the duration of the pulse, while the frequency and decrement depend on the constants of the receiver.

The oscillograms of Figures 1, 2, and 3 indicate a fast and slow time resolution of typical interference transients. Figure 1 shows impulses from natural atmospheric causes. These are induced surges on the antenna from radiation produced by lightning discharges. In *A* there is a continuous series of relatively high rate of rise voltage variations. This type of waveform will completely blanket communications for its duration. Some atmospherics are of the form shown in *C* containing relatively short duration pulses or groups of pulses with spaces between. Typical single pulses on a faster time base are given in *B* and *D*. The oscillograms at *E* and *F* show the atmospherics waveforms superimposed on the resultant of several strong local radio-frequency carriers.

Figure 2 shows several other examples of nature-made interference. From the noise reduction point of view, these differ from the atmospherics of Figure 1 in that it is possible in almost all cases to remove the source of interference. Figure 2*A* and *B* show corona discharge pulses on an aircraft antenna under precipitation static conditions. The typical individual corona pulse shown in *B* has a very steep wavefront and a slower decay with a width less than two-tenths of a microsecond. Slow sweep oscillograms as at *A* indicate maximum repetition rates in excess of 100,000 pulses per second. Figure 2*C* and *D* show interference pulses from windshield streamers. These are caused by flashovers on the windshield surface due to a high voltage produced by frictional charging of the windshield. Repeated oscillograms have shown a maximum pulse repetition rate of 100,000 pulses per second from streamers simulated in the laboratory. Figure 2*E* and *F* show noise pulses from laboratory-produced charged raindrops striking a bare-wire aircraft antenna. These pulses have amplitudes up to 500,000 microvolts and are steep enough to cause noise at radio frequencies up to 10 megacycles.

Figure 3 shows interference from several man-made

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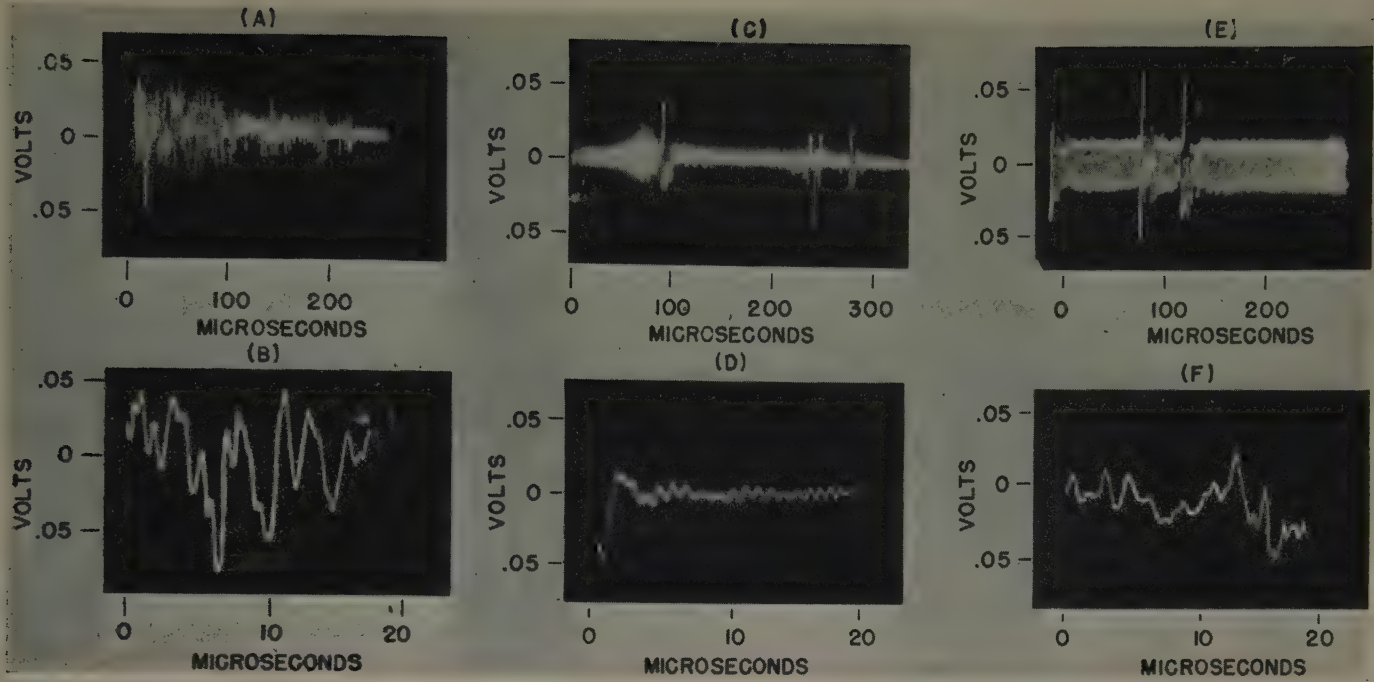

Figure 1. Typical waveforms caused by atmospherics

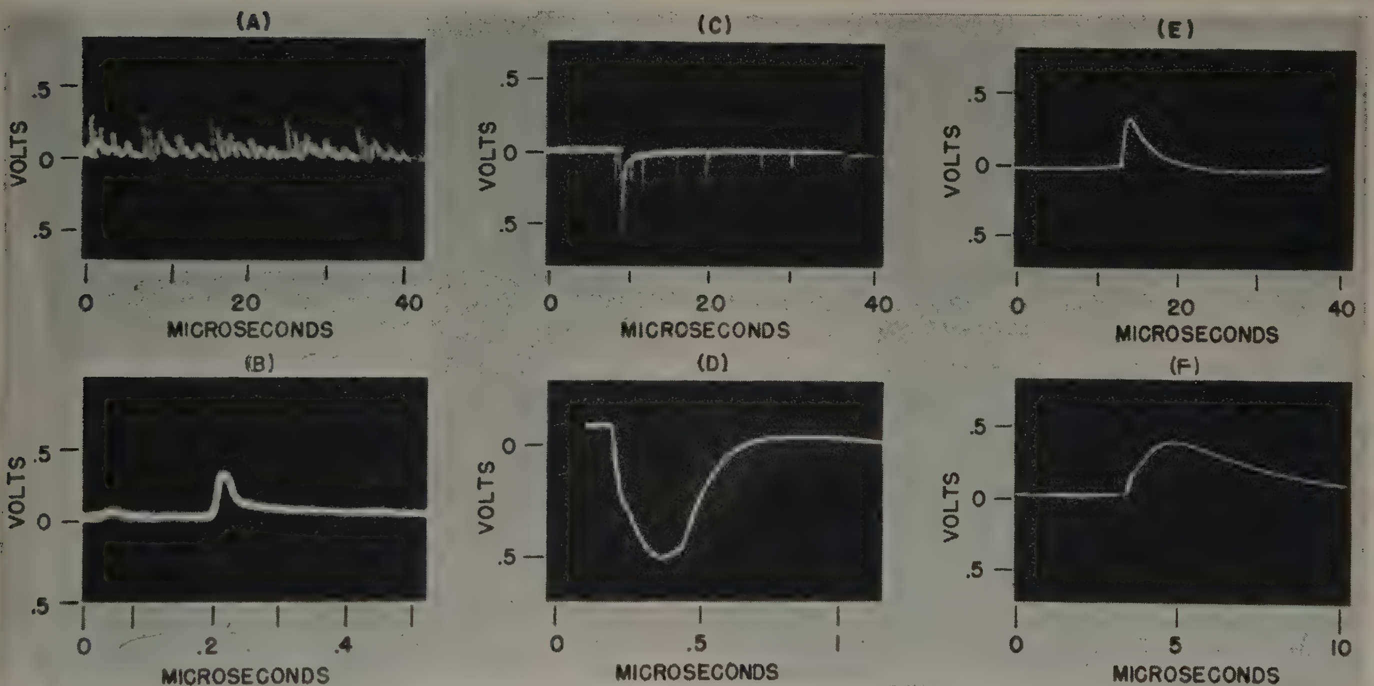

Figure 2. Typical nature-made interference waveforms

sources. Typical examples of motor-commutation transients shown in Figure 3*A* and *B* vary widely with condition of brushes and present a serious problem in that the number of pulses is larger than simple commutation functions would indicate, corresponding rather to a situation of continuous chattering of brushes on the commutator surface resulting in random repetition of the type of transient generated by the single chattering relay contact. Figure 3*C* and *D* show pulses across a relay coil caused by contact chattering of a series toggle switch. Amplitudes of these pulses reach values of the order of 1,000 volts, and, since aircraft have many relays, coupled interference from this source may be considerable. The pulses in Figure 3*E* and *F* were generated by an ordinary 24-volt aircraft vibrator. In *E* is a group of pulses associated with a single contact closing, caused by chattering of the contact.

Aircraft interference may be further classified as either direct or coupled interference. Of the sources of aircraft radio interference mentioned, one of the most common

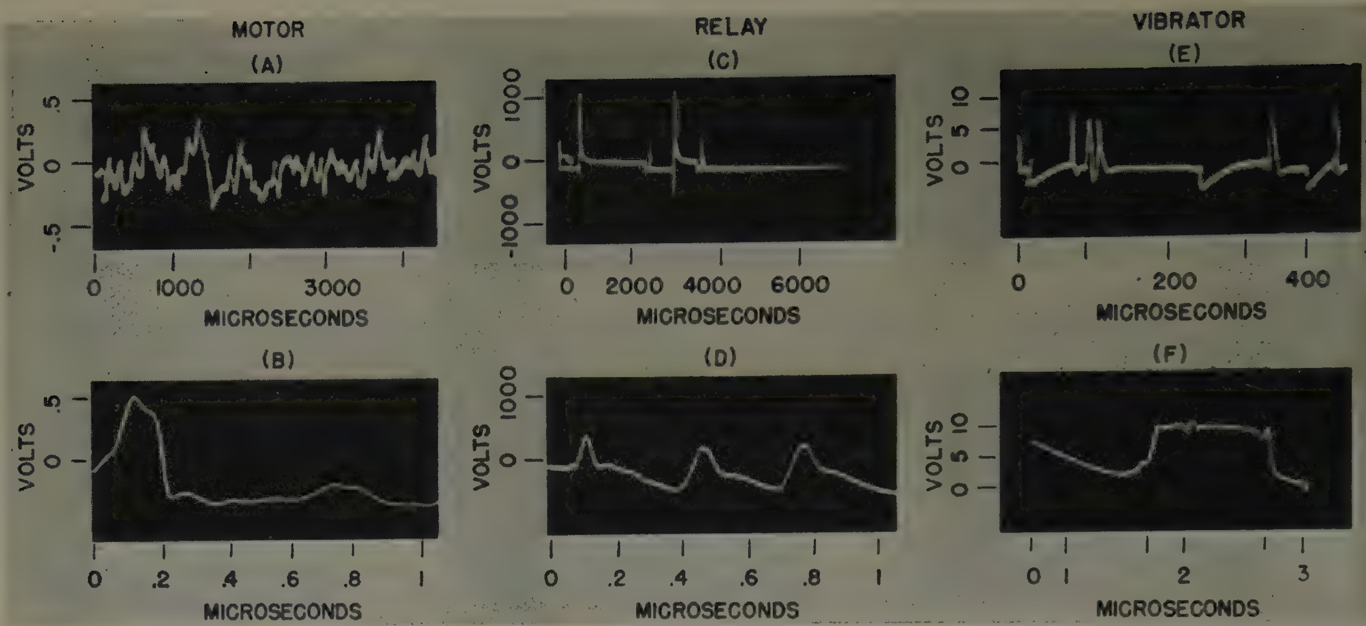

Figure 3. Interference waveforms from several man-made sources

is corona which occurs directly on bare-wire antennas when the aircraft passes through thunderstorm cross-fields or accumulates a charge due to frictional contact with atmospheric particles. Direct corona pulses have amplitudes of the order of 0.5 volt. However, this interference may be reduced at the source by using a polyethylene-insulated antenna which prevents corona on the antenna by a mechanism of charge deposition on the surface of the insulation sufficient to neutralize the field to such a degree that no further ionization occurs. However, during the process of variation of charge conditions some interference potentials are induced on the antenna, which largely disappear as a steady state is reached. Interference may be induced also from corona on other parts of the airplane such as the propeller and wing tips and other sharp projections from the aircraft. Figure 4 shows an oscillogram of a corona pulse on an aircraft very-high-frequency antenna mast together with the corresponding pulse coupled into a high-frequency antenna on the airplane. These two pulses were recorded simultaneously on a dual-beam oscillograph. The coupled pulse has an amplitude of 0.07 volt which is large enough to cause radio noise.

Charged rain drops impinging on a bare wire antenna also produce direct interference pulses, but induced pulses from this source produced when a rain drop passes near an antenna or strikes an insulated antenna probably do not have peak amplitudes and rates of rise sufficient to cause appreciable interference.

Most of the other sources of aircraft radio interference such as ignition noise, atmospherics, and motor noise may be classified as coupled interference.

MEASUREMENT TECHNIQUES

Most interference pulses are nonrepetitive (their repetition rates are not constant and the waveforms do not repeat). Such waveforms cannot be viewed with the repetitive sawtooth or driven sweeps commonly found

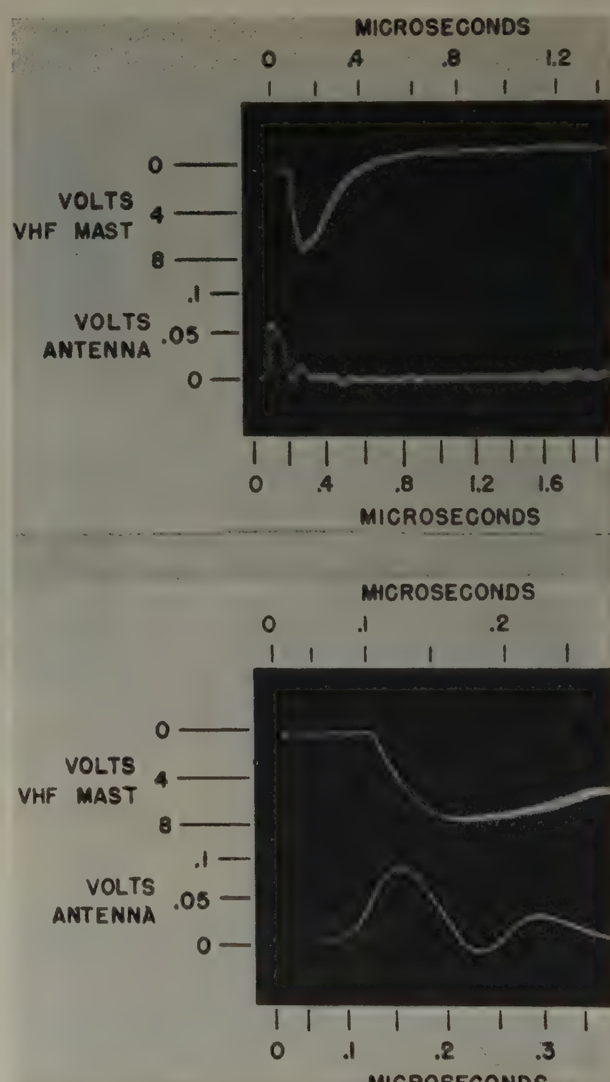

Figure 4. Oscillograms of a corona pulse on an aircraft antenna mast and the corresponding pulse coupled into a high-frequency antenna on the airplane

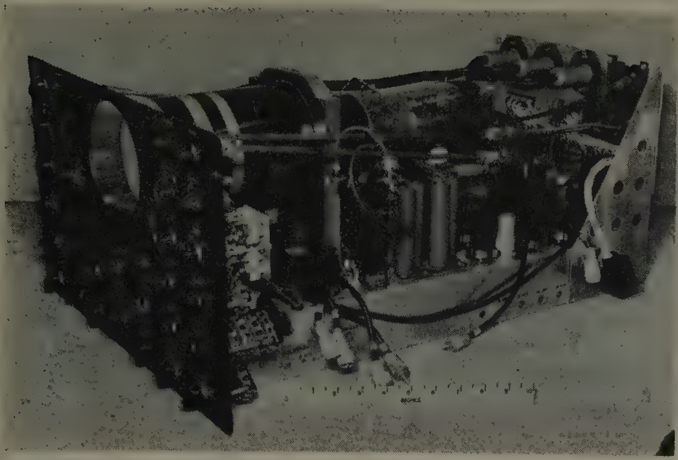

Figure 5. Side view of a wide-band dual-beam oscillograph

Figure 6. The wide-band (0.1 to 250 megacycles) amplifier used with the oscillograph shown in Figure 5

on most oscillographs. A single sweep, triggered preferably by the interference, is desirable along with a high intensification potential required for sufficient light intensity to photograph a single trace. A dual beam is also necessary for simultaneously photographing the effect of the interference pulse on coupled circuits. At least one of the dual channels should incorporate a wide-band distributed-type amplifier so that the interference pulse may be reproduced as accurately as possible. Early measurements of corona pulses with narrow bandwidth amplifiers resulted in oscillograms that showed pulses with lower amplitudes and rates of rise than those of the actual pulse due to the loss of high-frequency components.

A wide-band dual-beam oscillograph is shown in Figure 5. The unit is 14 inches high and is of relay rack width on all four sides. It has two separate channels each having all the requirements mentioned and in addition it has the driven and repetitive sweeps useful for general laboratory measurements. The cathode-ray tube is a dual-beam *5XP* with an intensification potential of 25 kv. One channel has a 10-megacycle amplifier and the other has a 0.1- to 250-megacycle distributed-type wide-band amplifier. The compact wide-band amplifier is shown in Figure 6. The output stage of this amplifier has a termination based on the distortionless line principle and provides a 2-inch undistorted deflection.

To reproduce corona interference conditions, a high-voltage d-c generator is necessary to simulate the high gradient electric fields such as may be encountered in flight. As illustrated in Figure 7, a high gradient field was simulated by placing a high-voltage electrode above the very-high-frequency mast. This electrode was connected to a 1,000-kv d-c generator located inside the laboratory building, Figure 8, and the voltage is brought out through the wide opening shown. The dual-beam oscillograph was connected to both the very-high-frequency mast and the antenna as shown in Figure 7. The streamering interference oscillograms shown in Figure 2 also were obtained with this experimental setup.

As an illustration of the usefulness of the dual-beam cathode-ray tube, the effect of a corona pulse at various stages in a receiver is shown in Figure 9. As can be seen

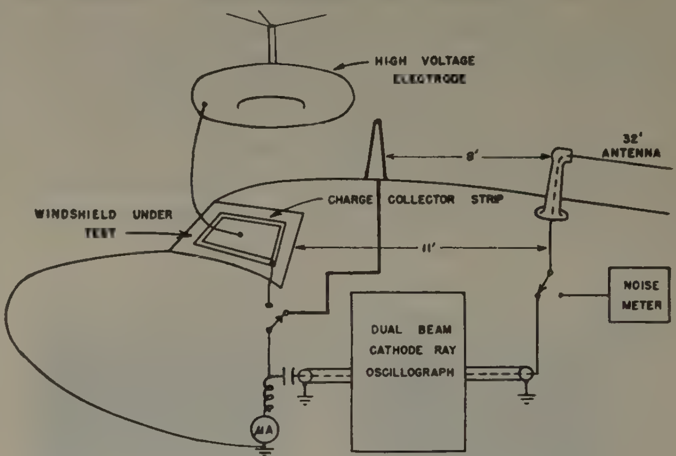

Figure 7. Diagram of the corona and windshield streamering measuring apparatus connections

Figure 8. The laboratory-airplane high-voltage test receives its power from a 1,000-kv d-c generator inside the building

from the figure, the very short interference pulse is greatly lengthened by the time it reaches the audio stage as a result of shock excitation. Figure 9*D* and 9*E* expand the first part of the shock excitation waveform by increasing the sweep speed of the lower trace. Audio distortion resulting from multiple interference pulses is presented in Figure 9*F*.

In studying nonrepetitive interference it is sometimes useful to record the pulses over a long time period. The interference is photographed on a sawtooth sweep with a moving film. Such an oscillogram of motor interference is shown in Figure 10 where the sweep period is 2,000 microseconds per trace. This method is limited to relatively low speed oscillography by the maximum film speed that can be attained to separate the traces.

While the oscillograph provides a graphical plot of the interference, the oscillograms, though complete, are sometimes difficult to interpret quickly. Other methods may be more useful for rapid noise analysis. One of these utilizes the technique of rapid electronic sampling of the outputs of a number of typical noise meters which are being tuned at the same time through their frequency ranges. The result is presented panoramically on one trace of a dual-beam cathode-ray tube with output amplitude plotted versus frequency. The interference pulse itself also may be presented on the other trace. This

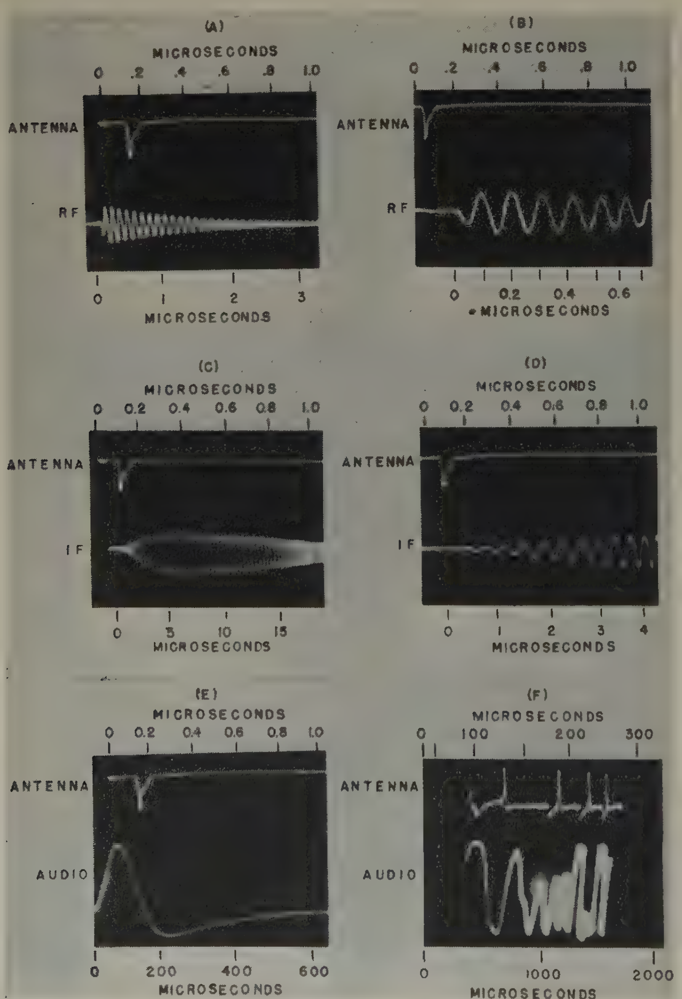

Figure 9. Effects of a noise pulse on different stages of a superheterodyne receiver

Figure 10. Motor commutation noise recorded on a continuously moving film

permits rapid coverage of a wide frequency range (0.1 to 700 megacycles in the analyzer under discussion).

Another noise-measuring device is a counter-type interference analyzer. This instrument indicates the following quantities, which appear to be the most important noise-producing characteristics of impulsive interference:

1. The average number of times per second that the applied interference waveform exceeds a given rate of rise.
2. The average number of times per second that the applied interference waveform exceeds a given amplitude.
3. The average value of the interference voltage.
4. The rate of occurrence of interference pulses that coincidentally exceed the given rate of rise and amplitude in items 1 and 2, during a period when the average voltage is above a given value.

It is hoped to characterize completely a given noise source by means of several meter readings giving these quantities and with this to predict the effects of the noise on any receiver or network over a wide frequency range.

CONCLUSION

For the purpose of aircraft radio-noise reduction an oscillograph capable of faithfully reproducing the interference pulses and their effects on receiving equipment provides the basic information necessary for developing effective methods of interference reduction either at the source or by circuitry. The oscillograms show the recurrence rate of the important properties of the interference from which the simplest and most effective method of noise reduction can be prescribed. For example, the low repetition rate of rain-drop interference indicates that normal audio noise limiting would be effective. As a consequence of the long receiver shock excitation waveforms, the high repetition rate of corona interference indicates that a noise rejection circuit located at the receiver input is necessary. The very high repetition rate and complex character of motor brush interference require noise removal at the source.

Although the oscillograph provides the basic information necessary for noise measurements, the other methods either can extend the usefulness of the noise meter technique or measure important noise characteristics directly.

Synthesis of Servomechanisms by Root Locations

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A PROCEDURE for synthesizing servomechanisms is introduced whereby the roots of the characteristic equations can be predicted. Given specified locations in the s plane for such roots, the open-loop gain and compensation can be calculated to give the desired locations.

The procedure is based on curvilinear square plots of the open-loop transfer function. Visualize the usual s plane plot made when working with the Nyquist diagram. The entire left half of the complex plane, starting at the j axis, may be divided into squares. The lines thus drawn are constant σ and constant ω lines ($s=\sigma+j\omega$). Since the only portion of the Nyquist diagram plotted with finite values corresponds to values of s along the plus j axis, then s plane squares may be transferred to the $KG(s)$ plane by a simple process of sketching them on the $KG(j\omega)$ locus. Figure 1 shows this for the example used to illustrate the process. The roots of the characteristic equation are then found by noting the values of the particular σ and ω contours that pass through the $-1+j0$ point. The method of synthesis is as follows:

1. Write the open-loop transfer function in factored form and plot the closure to determine stability from the Nyquist criterion.

2. Draw the curvilinear square contours in the most convenient plane. As a basis from which to start, the gain may be adjusted for a specified M_p in the usual manner.

3. From inspection of the open-loop transfer function, determine the approximate location of the real roots.

4. Determine the first root encountered moving left from the origin in the s plane. Use curvilinear squares to determine the first complex root, and $LmG(-\sigma)$ versus log $|\sigma|$ plots to determine the first real root.

5. Specify the line in the s plane to the left of which all roots of the characteristic equation must lie.

6. If the first root encountered is a complex root, select a specific location for this root, determine the gain, and/or phase shift necessary to move the root to the new location. If the first root encountered is a real root, determine the gain required to move this root left of the line specified in step 5, or near enough to a zero to be neglected.

7. From the phase shift required in step 6, determine the constants of the compensating network.

8. Check the physical realizability of the results.

The example shows how these steps are applied. From Figure 1 it is seen that the normalized roots ($s'=r+ju$) of the uncompensated system closest to the j axis are $-0.31\pm j0.76$. It is arbitrarily decided to make the roots closest to the j axis $-0.4\pm j1.2$. From the figure, the necessary phase shift to secure the desired change is seen to be 24.3 degrees. This can be accomplished with a resistance capacitance lead network whose transfer function is

$$\frac{1/\alpha_1\tau_1+s}{1/\tau_1+s}$$

The parameters are evaluated at $s'=0.41+j1.2$ to give a phase shift of $+24.3$ degrees. The transfer function of the compensated system, after gain adjustment, is

$$G(s)=59.8(2.22+s)/s(0.0014s+1)(0.026s+1)(0.01s+1)^{-}(22.2+s)$$

The roots added by a compensating network are handled in the same manner as the "original" roots. In the example, a real root near the j axis is added. However, since this root lies close to a zero of the closed loop, the coefficient associated with this root in the transient response is small and the effect of this root negligible.

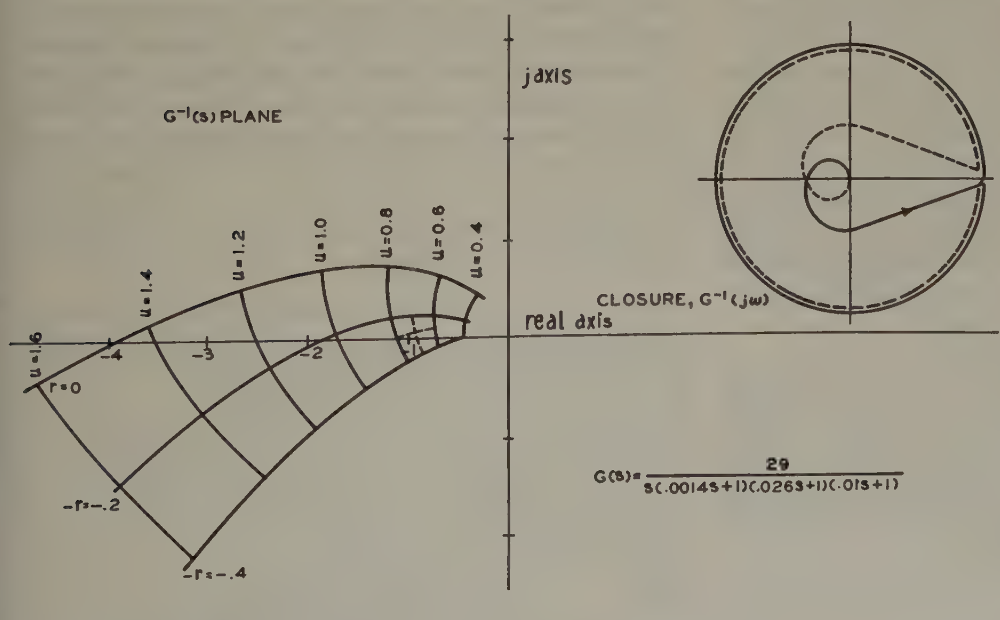

Figure 1. Curvilinear square plot, uncompensated system

Digest of paper 52-82, "Synthesis of Closed Loop Systems Using Curvilinear Squares to Predict Root Location," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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A Quadrature-Phase-Shift Voltage Transformer Device

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A QUADRATURE-PHASE-SHIFT voltage transformer was designed and built to assist in the analysis of circuit parameters of single-phase induction motors from test results. It could be used for other applications having similar basic requirements.

A high-accuracy portable voltmeter and the potential coil of a similar type wattmeter take a measurable amount of power for their operation. The average is about 8 to 10 watts for the two in parallel at 115 volts. In some cases, especially those involving induced or generated voltages, this meter burden would make the test reading inaccurate.

The input impedance to the device is high so that it will not load the output of the circuit to which it is connected. Its power output will operate a voltmeter and a wattmeter potential coil connected in parallel up to 150 volts. The low input tap is for voltages from 0 to 150 with an input impedance of 200,000 ohms. Likewise, the high input tap is for voltages from 0 to 300 with an input impedance of 400,000 ohms.

A phase-shift circuit has been included in the device with a switch to cut it in or out. It has a gain of 1 to 1 so that it does not change the output voltage. It does shift the phase of the voltage 90 degrees. Without this part of the circuit, the input and output voltages are in phase for all values within the voltage rating of the device. With it in the circuit, the voltages are the same but the output voltage is shifted 90 degrees from the input. A polarity switch also is provided for reversing the output voltage 180 degrees.

The device can be operated with an over-all voltage ratio of 1 to 1 or it can be varied in small increments to a low ratio of 0.3 to 1 or a high ratio of 3 to 1. An accurate 3-decade attenuator is provided for setting the over-all voltage ratio.

Provisions are included for calibrating the voltage ratio and the phase angle of the device.

To measure reactive volt-amperes, the input of the device is connected to the line with the 90-degree phase shift switched in the circuit. A single-phase wattmeter has its potential coil connected to the output of the device and the current coil is connected in series with the load. With the 90-degree displacement in the voltage to the potential coil, a standard wattmeter will read the reactive volt-amperes of the circuit.

The reactance of the circuit can be determined by measuring the line current in addition to the foregoing value of reactive volt-amperes and using the following equation: $x = \text{VARS}/_I{}^2$.

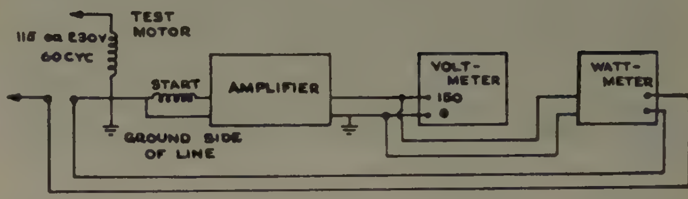

Figure 1. Schematic diagram of motor connections to line and amplifier

For low input voltages that usually cannot be read accurately because of their position on the scale, the amplifier ratio is increased to give an accurate reading and then the meter readings are divided by this ratio.

To measure the magnetizing reactance of a single-phase induction motor, it is connected to the line and the device as shown in Figure 1. The device is set for the input and output voltages to be in phase. In combination with a motor input-reactive-power measurement the value of the magnetizing reactance plus the primary leakage reactance is obtained. A companion paper[1] describes this application in detail.

To measure the output of a single-phase motor, the connections also would be according to Figure 1 except the device would have the 90-degree phase shift switched in the circuit. Since the auxiliary winding is displaced 90 degrees in space, the second 90-degree electric phase shift, together with the polarity switch which gives a 180-degree shift, makes it possible to apply a voltage to the potential coil of the wattmeter that is in phase with the main winding generated volts. The voltage ratio of the device is set inverse to the ratio of auxiliary winding effective turns to main winding turns so the voltage also will have the same value as the main winding.

The wattmeter then reads the synchronous watts output or

$$W = \frac{I^2(R_{2f} - R_{2b})}{2}$$

where

R_{2f} = apparent forward field secondary resistance

R_{2b} = apparent backward field secondary resistance

Using the synchronous watts output and synchronous speed, the output torque may be determined directly.

The gross power output equals the synchronous watts output times $(1-s)$ where s = slip.

Digest of paper 52-49, "A Quadrature-Phase-Shift Voltage Transformer Device and Its Applications," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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The authors wish to acknowledge the work of M. W. Hellar, Jr., General Engineering Laboratories, General Electric Company, Schenectady, N. Y.

REFERENCE

1. Toward an Accurate Evaluation of Single-Phase Induction-Motor Constants, F. W. Suhr. AIEE *Transactions*, volume 71, 1952 (*Proceedings T2-48*).

Computing Machines in Aircraft Engineering

C. R. STRANG

A critical evaluation of computing machinery is given from the viewpoint of the aeronautical engineer. The machines' limitations are presented together with suggestions to make them more useful to the aircraft industry.

THIS IS a user's critical view of computing machinery with emphasis on its limitations. Therefore, it is an inversion of the situation in which the aircraft manufacturers usually find themselves. They are normally the supplier rather than the user, and the users of their products rarely need any encouragement to present their views in a very critical manner.

Aircraft, like computing machines, are complicated to design and difficult to build. Those who work with aircraft design problems are understanding and sympathetic with the difficulties involved in computing machine design.

Aeronautical engineers have gone far enough to see that there are special problems in making really full scale use of machine computing in their engineering work. There are marked differences between this work and the more academic or scientific applications for which many of the present machines were developed.

It may be helpful to have an idea of how much of a user of computing equipment the Douglas Aircraft Company actually has been. In considering these data, it should be kept in mind that a rather practical engineering viewpoint is held. The people doing this work do not consider themselves scientists and do not undertake mathematical investigations for the sheer intellectual joy of doing so. Furthermore, not all the work done is dependent on large-scale calculations. Probably about 15 to 20 per cent of the total work is mathematical in nature. Much of that work is a miscellany of casual calculations too small to benefit from high-speed computing machinery. On the other hand, a great deal of the mathematical work tends to be concerned with operations that occur early in the formative stages of the design when much of what follows can be only tentative until the calculations are well advanced. Most of the remainder of the work is concerned with formal demonstration that the design complies with all its requirements.

USE OF COMPUTING EQUIPMENT BY DOUGLAS

THE GROWTH in number of personnel whose time was fully devoted to manipulating computing equipment installed on the premises is shown in Figure 1. It does not include the time of the engineering personnel who were the customers for the computing services and who participated in its performance, nor does it include the staffs of outside equipment when working on these problems. Obviously, beyond this present date, it is necessary to estimate the probable number of people whose services will be required. This was done on the basis of the additional equipment on order and still to be received through the end of 1952. As a parenthetical remark, the majority of these people have backgrounds in classical mathematics and physics. In the present shortage of trained engineering personnel it is important that computing machinery has enabled the aircraft industry to take real advantage of the services of a group of people whose training otherwise would have been of limited value.

The growth of the floor space that has had to be devoted to installation of computing machines in the Southern California plants is shown in Figure 2. Figure 3 plots the total power requirements of the various equipment as anticipated through the end of 1952. These considerations are minor by comparison with the question of dollars involved. Figure 4 indicates the order of the direct cost in terms of actual machine cost or rental, salaries, and directly chargeable items, but not including general plant overhead, as anticipated through the end of 1952.

There unquestionably has been an appreciable dollar saving in the accomplishment of work by machine versus manual methods. This direct saving is only one of several reasons for the industry's interest in computing machinery. It will be clear later that refined engineering design is a repetitive process. Where machine computing makes it economically feasible to accomplish a closer approach to the ideal, the value realized in terms of a better design has a magnitude hard to determine in dollars and cents. Most vital of all is the saving in elapsed time. As mentioned previously, much of the work to be done during the formative stages of a design is only tentative. It is subject to change and deprived of final status until a large and growing volume of calculations are performed. When that work can proceed on a firmer basis, much waste of engineering time is avoided. Here a real saving is accomplished in the effectiveness of the work of hundreds of engineering personnel who may have had nothing whatever to do with the computing machines.

TYPES OF MACHINES USED

PREVIOUSLY, the equipment actually installed in the plants has been a changing combination of International Business Machines (IBM) punched card tabulating machinery. However, Figures 1 through 4 reflect the fact that an electric analogue machine of the type developed at California Institute of Technology by Dr. McCann and his associates, and being built by the William Miller Company of Pasadena under the guidance of Dr. McCann, was put into service in July 1952. The nature of that equip-

Revised text of a paper presented at the joint AIEE–Institute of Radio Engineers Computer Conference, Philadelphia, Pa., December 10–12, 1951.

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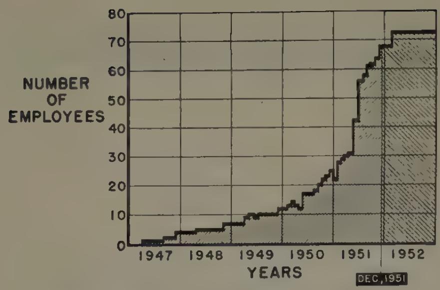

Figure 1. Growth in number of personnel needed for computing equipment

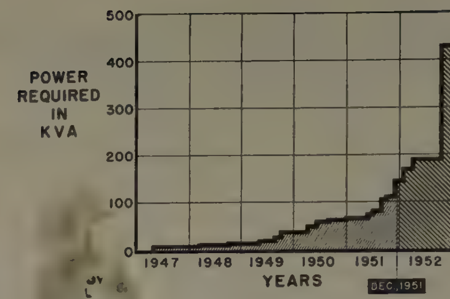

Figure 3. Total anticipated power requirements for equipment through 1952

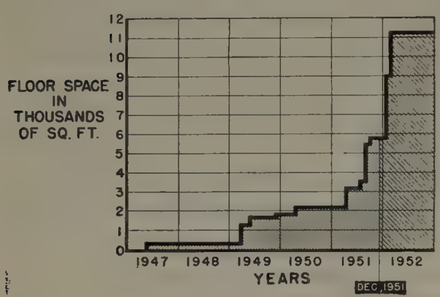

Figure 2. Growth of floor space needed for installation of computing machines

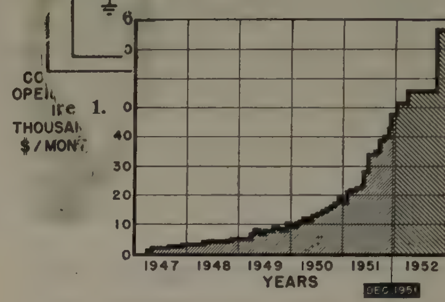

Figure 4. Cost in terms of machine cost or rental, salaries, and directly chargeable items exclusive of plant overhead

ment and some of the techniques developed for its use have appeared in AIEE and Institute of Radio Engineers (IRE) papers by Dr. McCann.[1–3] The curves also anticipated the installation of a new Reeves Electric Analogue Computer. It took over in March 1952 work that was being done on another similar installation outside of the company. The large jump in dollars and power consumption shown at the end of 1952 reflect the hope that at that time the two IBM Defense Calculators currently on order will be available and actually will go into service. Equipment-wise this adds up, at the end of 1952, to

2 Defense Calculators (IBM)
5 Card Programmed Calculators (IBM)
1 Electric Analogue (William Miller Company)
1 REAC (Reeves Instrument Company)
Miscellaneous IBM 604 electronic calculators and associated equipment

This equipment will be distributed, as the present equipment, among the three plants in the Los Angeles area.

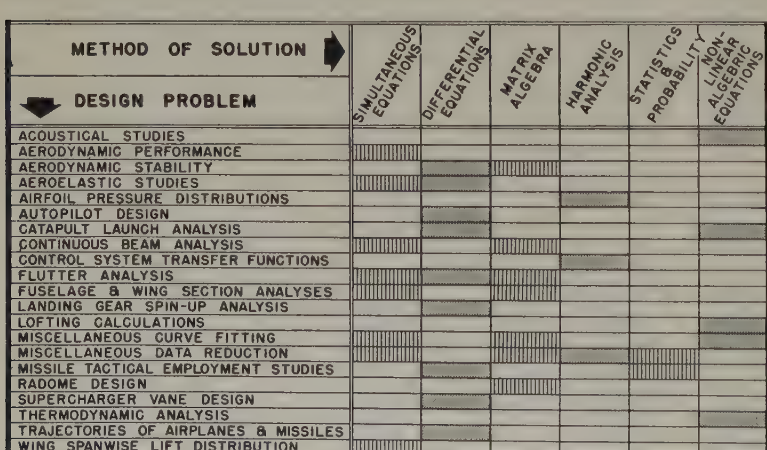

Figure 5. Some typical aircraft engineering problems solved using automatic computing equipment

In addition to these facilities which are operated as an integral part of the engineering departments, there have been a number of projects which for one reason or another were carried out on various outside computing facilities. In such cases, of course, the projects were conducted largely by the staffs associated with those facilities. These have included a number of investigations, some of them extremely interesting in their nature, on the:

Meteor (Massachusetts Institute of Technology)
analogue (California Institute of Technology)
General Electric mechanical differential analyzer (University of California at Los Angeles)
thermal analyzer (University of California at Los Angeles)
Bell Telephone Company GPAC
Project Typhoon
Project Cyclone
REAC

As a company Douglas has designed and built several devices in the general category of computing equipment. Also, in the normal course of its work on several missile projects, it has been exposed to the computing equipment phases of the guidance systems involved.

PROBLEMS SOLVED

The projects in broad general classifications indicating physical nature, together with the nature of the controlling mathematical procedures involved, are listed in Figure 5. The list is not complete and does not, by any means, represent all of the applications which the total scope of the engineering work will ultimately require.

Up to this point, data have been presented in a necessarily superficial way to show something of the scale of the work on, and famili-

$$\frac{\partial^2}{\partial x^2}\left[EI\frac{\partial^2 y}{\partial x^2}\right] + \frac{m\partial^2 y}{\partial t^2} \pm S_\alpha \frac{\partial^2\alpha}{\partial t^2} = -\pi\rho\, b^2(x)\frac{\partial^2 y}{\partial t^2} - \pi\rho V\, b^2(x)\frac{\partial\alpha}{\partial t} - 2\pi\rho V\int_0^t \phi(x,t-\tau)\left[b(x)\frac{\partial^2 y}{\partial\tau^2} + b^2(x)\frac{\partial^2\alpha}{\partial\tau^2} + Vb(x)\frac{\partial\alpha}{\partial\tau}\right]d\tau + f(x,t)$$

$$\frac{\partial}{\partial x}\left[GJ\frac{\partial\alpha}{\partial x}\right] \pm S_\alpha\frac{\partial^2 y}{\partial\tau^2} + I_\alpha\frac{\partial^2\alpha}{\partial\tau^2} = -\pi\rho\frac{b^3(x)}{2}\frac{\partial^2 y}{\partial t^2} - \pi\rho\frac{b^4(x)3}{8}\frac{\partial^2\alpha}{\partial t^2} - \pi\rho V\, b^3(x)\frac{\partial\alpha}{\partial t} + g(x,t)$$

L E G E N D

- EI = BENDING RIGIDITY OF WING
- GJ = TORSIONAL RIGIDITY OF WING
- m = MASS PER UNIT LENGTH OF WING
- S_α = UNBALANCE MOMENT PER UNIT LENGTH OF WING
- I_α = MASS MOMENT OF INERTIA PER UNIT LENGTH OF WING
- ρ = DENSITY OF AIR
- $b(x)$ = SEMI-CHORD OF WING

- V = FORWARD VELOCITY OF WING
- $\phi(x,t-\tau)$ = LAG FUNCTION DESCRIBING GROWTH OF LIFT ON WING
- $f(x,t)$ = ARBITRARY FORCING FUNCTION
- $g(x,t)$ = ARBITRARY FORCING FUNCTION
- $\alpha(x)$ = ANGULAR COORDINATE DESCRIBING TORSION OF WING
- $y(x)$ = VERTICAL COORDINATE DESCRIBING VERTICAL TRANSLATION OF WING

THE EQUATIONS FOR THE MECHANICAL SYSTEM ARE SOLVED BY WRITING THEM IN THE FOLLOWING FINITE DIFFERENCE FORM, WHICH IS ALSO A SET OF EQUATIONS DESCRIBING AN ELECTRICAL NETWORK.

(1) ELASTIC

$$\left.\frac{\partial\frac{\partial y}{\partial t}}{\partial x}\right|_{x=x_{n}+\frac{1}{2}} = \frac{\left.\frac{\partial y}{\partial t}\right|_{n+1} - \left.\frac{\partial y}{\partial t}\right|_{n}}{\Delta x_{n+\frac{1}{2}}} \qquad EI_n\left.\frac{\partial\theta}{\partial x}\right|_{x=x_n} = -EI_n\frac{\int\left(\left.\frac{\partial\theta}{\partial t}\right|_{x=n+\frac{1}{2}} - \left.\frac{\partial\theta}{\partial t}\right|_{x=n-\frac{1}{2}}\right)dt}{\Delta x_n}$$

$$\left.\frac{\partial M}{\partial x}\right|_{x=x_n+\frac{1}{2}} = \frac{M_{n+1}-M_n}{\Delta x_{n+\frac{1}{2}}} \qquad \left.\frac{\partial Q}{\partial x}\right|_{x=x_n} = \frac{S_{n+\frac{1}{2}}-S_{n-\frac{1}{2}}}{\Delta x_n}$$

$$\left.\frac{\partial\alpha}{\partial x}\right|_{x=x+\frac{1}{2}} = \frac{\alpha_{n+1}-\alpha_n}{\Delta x_{n+\frac{1}{2}}} \qquad \left.\frac{\partial\alpha}{\partial x}\right|_{x=x_{n-\frac{1}{2}}} = \frac{\alpha_n-\alpha_{n-1}}{\Delta x_{n-\frac{1}{2}}}$$

$$\frac{\partial}{\partial x}\left(GJ\frac{\partial\alpha}{\partial x}\right)_{x=x_n} = \left[GJ_{\left(x_{n+\frac{1}{2}}\right)}\frac{\int\left(\frac{\partial\alpha_{n+1}}{\partial t}-\frac{\partial\alpha_n}{\partial t}\right)dt}{\Delta x_{n+\frac{1}{2}}} + GJ_{\left(x_{n-\frac{1}{2}}\right)}\frac{\int\left(\frac{\partial\alpha_{n-1}}{\partial t}-\frac{\partial\alpha_n}{\partial t}\right)dt}{\Delta x_{n-\frac{1}{2}}}\right]\frac{1}{\Delta x_n}$$

(2) MASS

- $\Delta x m_n$ = MASS OF nth CELL
- $\Delta x S_\alpha$ = UNBALANCE MOMENT OF nth CELL
- $\Delta x I_\alpha$ = MOMENT OF INERTIA OF nth CELL

(3) AERODYNAMIC APPARENT MASS COEFF.

$$\Delta x_n\pi\rho b^2(x_n),\ \Delta x_n\pi\rho b^4(x_n)\tfrac{3}{8}\quad \Delta x_n\pi\frac{\rho b^3(x_n)}{2}$$

(4) AERODYNAMIC DAMPING COEFF.

$$\Delta x\pi\rho V b^2(x_n),\ \Delta x\pi\rho V b^3(x_n)$$

(5) AERODYNAMIC FORCES (CIRCULATORY)

THE INTEGRAL IN THE EQUATIONS OF MOTION MAY BE WRITTEN IN THE FOLLOWING OPERATIONAL FORM:

$$\left[\Delta x 2\pi\rho V\int_0^t\phi(x_n,t-\tau)\left(b(x_n)\frac{\partial^2 y}{\partial\tau^2} + b^2(x_n)\frac{\partial^2\alpha}{\partial\tau^2} + Vb(x_n)\frac{\partial\alpha}{\partial\tau}\right)d\tau\right] =$$

$$\Delta x 2\pi\rho V\left(\phi(x_n,p)\right)\left(b(x_n)py + b^2(x_n)p\alpha + Vb(x_n)\alpha\right)$$

$$\left(\phi(x_n,t)\right) \cong \frac{a_1 + a_2\frac{b(x_n)}{V}p}{a_3 + a_4\frac{b(x_n)}{V}p}$$

Figure 6. Typical wing bending–torsion flutter equations

arity with, computing devices. The rate at which that phase of the work is growing, how it compares with the total engineering operation, and something of what has been done with it so far have been indicated however.

To those to whom the scale of these operations seems large, the question naturally will arise as to what is so particularly difficult about airframe design as to need so much engineering and computing. The answer is sardonically implied in one of the favorite definitions of the industry's products, which declares that an airplane is a thing that almost does not work, while a missile is a thing that almost does. The difficulties involved are amply attested to by the unfortunate fact that most airplane designs are failures. In this philosophy, a successful airplane is one that contributes more to society than it costs. It is believed that when a particular design satisfies this definition, its history will be characterized by long production life, repeated reorders, and wide application. There have been thousands of different airplanes designed and built in the last 45 years and pitifully few that could be considered successful by such a standard. Furthermore, the technical difficulty involved mounts tremendously with increasing flight speeds. Unfortunately, the cost involved goes up to some power of these complications and the penalties of inadequate or misdirected engineering effort go up accordingly.

AERONAUTICAL ENGINEERING METHOD

It is clear that the more scientifically minded sometimes tend to be horrified and disappointed with aeronautical engineers when it is discovered how they operate. Unfortunately, the present state of the engineering art does not permit them to solve directly for a design of anything to do any stipulated job. They have to work the other way around. A design is proposed that might do the job. All their techniques are such that they pertain to the performance of the proposed design. This performance is then compared with the desired and, in general, is found wanting. The proposed design is changed, the technique applied again, and the new performance compared with the desired, and so on. This is true whether the problem involved is large or small, whether it is the design of a structural member to carry a load, a supercharger vane to move enough air, or an airplane to possess a given rate of climb with one engine out, landing gear up, and flaps down, for example. Furthermore, the total number of variables involved are so great that no one yet has proposed a computing facility that could handle them all as one problem, even if we had reached the stage where we could express them as one problem.

DIGITAL VERSUS ANALOGUE MACHINES

Although the interest here lies primarily in digital machines, it has been found desirable to use both physical and mathematical analogues as well as digital machines and their use is expected to continue indefinitely. As computing machine users, aeronautical engineers view as futile the arguments as to the relative merits of digital versus analogue machines, or mathematical analogues versus true physical analogues. They think there is room, and need, for all. Their interests would be better served if the proponents of each took a generous view of the

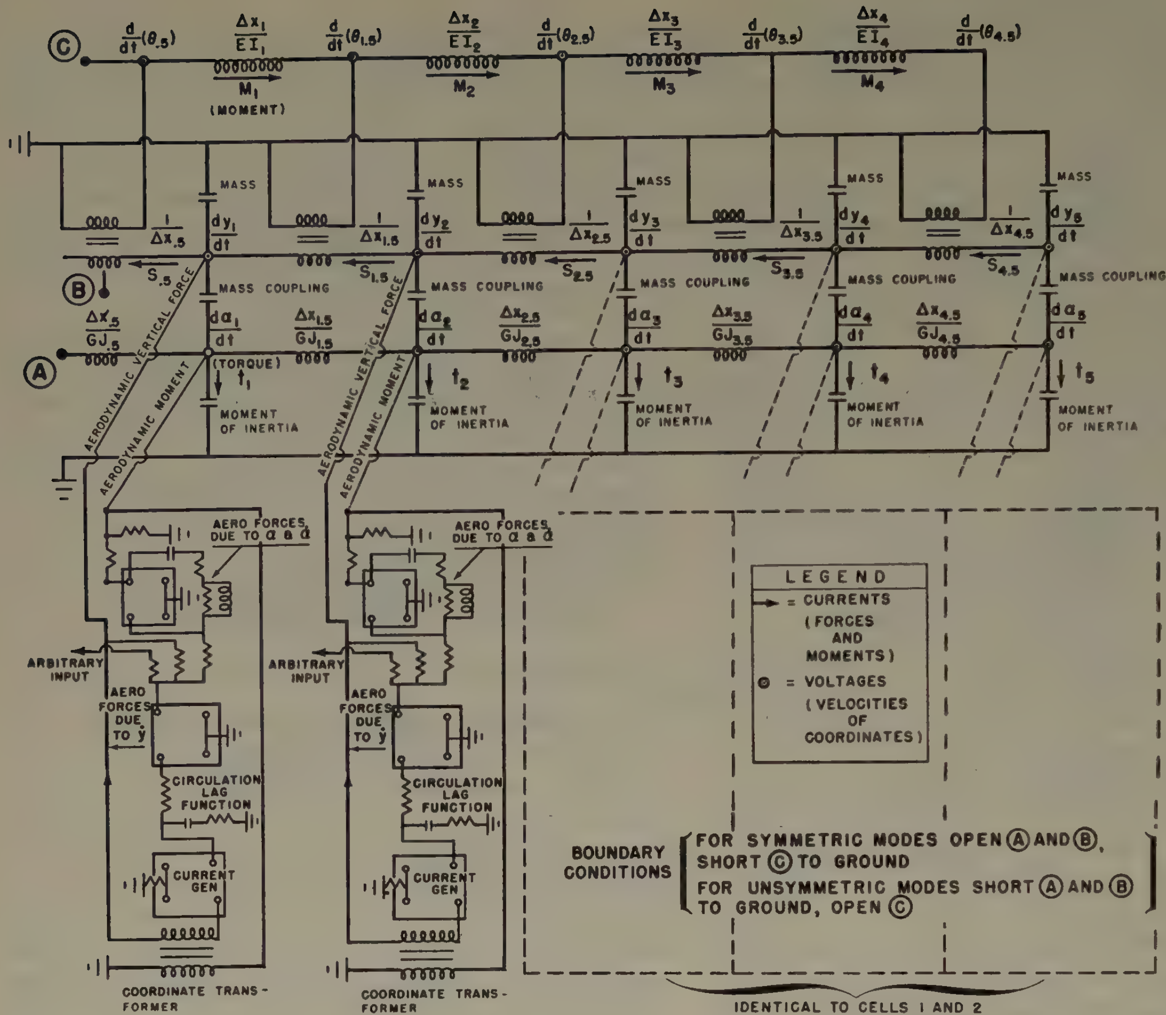

Figure 7. Circuit for typical wing bending – torsion flutter problem

advantages of the other and tried to incorporate comparable advantages in his own design.

COMPUTER MACHINE APPLICATIONS

TWO PARTICULAR APPLICATIONS have been selected for presentation in a descriptive nontechnical way to convey something of the situation into which computing machinery must fit to become an integral fully effective part of an operating engineering department.

The first application selected as an example is a flutter problem. The flat plane of a wing or tail surface forced through the air edgewise wants to wave like a flag, that is, to flutter. Deflection modes of wings, fuselage, and tail surfaces may want to interact with and mutually reinforce each other. Since they are deriving energy meanwhile from the passing air stream, a sufficiently high speed will cause the oscillations to build up to the point that something fails. The mechanism is very much as if the aerodynamic forces interacting with the elastic and inertia forces within the structures had constituted themselves into a mechanical analogy of what is going on electrically in an oscillating electric circuit. It also could be compared to the stability of a closed loop servomechanism system. It is the designers' purpose to keep the critical speed at which this whole process becomes catastrophic safely above any speed at which the particular airplane or missile ever will fly.

During the last 6 years, the mathematical procedures involved have been adapted to IBM punched card tabulating and computing equipment to the point that about 90 to 95 per cent of the work is mechanized. This has benefited us enormously at a time when much higher flight speeds and the thin airplane and missile surfaces typical of high-speed design have greatly increased the probability of flutter.

As an example, the preliminary conventional flutter analysis for a recent model indicated that its critical flutter

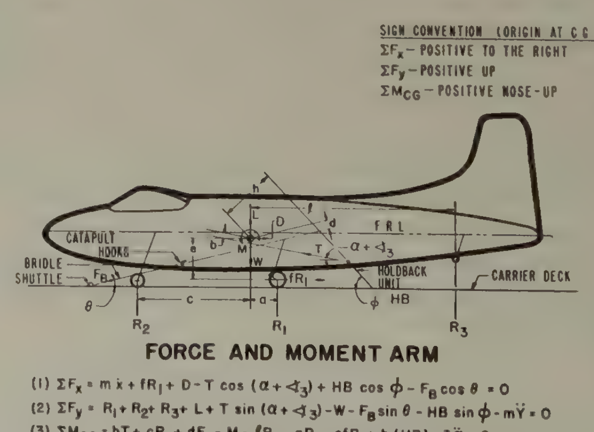

Figure 8. Catapult take-off diagram

$$4)\ \left[\frac{y-K_{25}+K_7\cos\alpha-K_6\sin\alpha+K_{14}\sin(\angle_4+\alpha)}{\sin(\angle_4+\alpha)}\right]^2+K_{50}=K_{51}\bar{y}-\bar{y}^2-\left[\frac{\delta_1-\bar{y}\cos(\angle_4+\alpha)}{\sin(\angle_4+\alpha)}\right]^2-\frac{2\left[y-K_{25}+K_7\cos\alpha-K_6\sin\alpha+K_{14}\sin(\angle_4+\alpha)\right]\left[\delta_1-\bar{y}\cos(\angle_4+\alpha)\right]}{\sin^2(\angle_4+\alpha)}$$

$$5)\ F_8=\frac{K_4+K_3(K'_5)-K_2\cos(\alpha+\angle_3)+H.B.\cos\phi+K_1\left[K_8+K_9t\right]^2}{\cos\theta}$$

$$6)\ \ddot{y}=\frac{K'_5+K'_{15}+K_{13}\left[(K_8+K_9t)^2(\alpha+\angle_1)-K_{29}(K_8+K_9t)(\dot{y})\right]+K_2\sin(\alpha+\angle_3)-K_{16}-F_8\sin\theta-H.B.\sin\phi}{K_{17}}$$

$$7)\ \ddot{\alpha}=\frac{K_{20}+\left[y\cos\theta-\sin\theta\,(K_{12}\cos\theta+K_{11}\sin\alpha+K_{10}\cos\alpha)\right]\left[F_8\right]-\left[K_7\sin\alpha+K_{19}\cos\alpha-\overset{\equiv}{y}\sin(\alpha+\angle_5)+\frac{K_{24}}{\cot(\angle_5+\alpha)}\right]\left[K'_{15}\right]}{K_{22}}$$

$$\frac{-\left[K_7\sin\alpha+K_6\cos\alpha-K_{14}\cos(\angle_4+\alpha)-K_{21}\sin(\angle_4+\alpha)+K_{32}\cos(\angle_4+\alpha+T)\right]\left[K'_5\right]-\left[y-(K_{25}-\delta_1)\right]\left[K_3\right]\left[K'_5\right]+\left[H.B.\right]\left[h\right]}{K_{22}}$$

$$\frac{-K_{23}\left[(K_8+K_9t)^2(\alpha-\angle_2)-K_{29}(K_8+K_9t)(\dot{y})\right]-K_{31}(K_8+K_9t)(\dot{\alpha})}{K_{22}}$$

$$\theta=\sin^{-1}\left[\frac{y-K_{11}\cos\alpha+K_{10}\sin\alpha}{K_{12}}\right]$$

$$\phi=\sin^{-1}\left[\frac{y-K_{26}\sin\alpha-K_{27}\cos\alpha}{K_{28}}\right]$$

$$\overset{\equiv}{y}=\frac{K_7\cos\alpha-K_{19}\sin\alpha+y}{\cos(\angle_5+\alpha)}$$

$$\bar{y}=\frac{K_{18}\sin\alpha+K_7\cos+y}{\cos(\angle_6+\alpha)}$$

$$H.B.\cos\phi=K_{30}+K_{34}t$$

$K'_5=K_5(1\pm K_{35})$ WHEN $\bar{y}_n<\bar{y}_{n-1}$ K_{35} is POSITIVE
WHEN $\bar{y}_n>\bar{y}_{n-1}$ K_{35} is NEGATIVE

$K'_{15}=K_{15}(1\pm K_{36})$ WHEN $\overset{\equiv}{y}_n<\overset{\equiv}{y}_{n-1}$ K_{36} is POSITIVE
WHEN $\overset{\equiv}{y}_n>\overset{\equiv}{y}_{n-1}$ K_{36} is NEGATIVE

$K'_{15}=K_{60}(K_{52}-\overset{\equiv}{y})+K_{61}$ WHEN $\overset{\equiv}{y}<K_{52}$

$$h=K_{26}\sin(\phi-\alpha)-K_{27}\cos(\phi-\alpha)$$

$$\beta=\alpha-\frac{y(K_{29})}{(K_8+K_9t)}$$

$$\sin T=\frac{\bar{y}-K_{21}}{K_{32}}$$

$$\alpha_{n+1}=\alpha_n+\dot{\alpha}_n\Delta t+\frac{\ddot{\alpha}_n(\Delta t)^2}{2}$$

$$\dot{\alpha}_{n+1}=\alpha_n+\ddot{\alpha}_n\Delta t$$

$$y_{n+1}=y_n+\dot{y}_n\Delta t+\frac{\ddot{y}_n(\Delta t)^2}{2}$$

$$\dot{y}_{n+1}=\dot{y}_n+\ddot{y}_n\Delta t$$

Figure 9. Catapult take-off analysis

speed would be far too low. In this particular case, it was decided to supplement the usual approach by dealing with the problem in all its ramifications on the analogue machine at California Institute of Technology. Figure 6 gives a typical formal statement of the problem. Figure 7 indicates the general nature of the circuitry involved. During the preliminary analysis, the analogue confirmed the predictions of the conventional analysis that flutter was inevitable. As a result, 126 design changes were considered to remedy this condition. This meant that 126 separate investigations of mathematical systems similar to those shown by Figure 6 except that the actual case was appreciably more complex. After design decisions based on these 126 solutions had firmed up the redesign, the nearly final version was again put back into the machine and 50 more solutions covering numerous variations were made.

A CATAPULT PROBLEM

THE SECOND CASE has to do with solving the equations of motion of a catapulted airplane at the instant it is air-borne. It is typical of that class of problems which are fundamentally simple but become odious mathematically when many necessary details are taken into account. When a mission requires a naval airplane operating from a carrier to take off at weights greater than it can take off under its own power, some assistance, usually in the form of a catapult, is used to attain flight speed.

A diagram of a modern tricycle landing gear airplane intended for such operations is shown in Figure 8. This figure also shows the equations of motion which describe the fact that such an airplane, during the few seconds of its catapulting run and under the influence of all the forces acting during that time, tends to rock back and forth alternately between nose wheel and tail wheel. Each of these introduces forces which are functions of the load-stroke characteristics of their respective shock-absorbing systems. These forces, incidentally, not only inject mathematical discontinuities but involve a hysteresis loop that is the result of the fact that the load-stroke curve is not the same when the shock strut is moving in as it is when the shock strut is moving out. In other words, these discontinuous forces are nonlinear. Lift, drag, thrust, and acceleration forces are, of course, changing continuously. Taking all these mathematical complications into account expands the simple equations of motion shown on Figure 8 into the situation shown by Figure 9. These problems obviously would be long and arduous to solve by manual methods, as was clear when it was attempted on a much simpler project than this. Nevertheless, their solution was absolutely necessary because some combination of dimensions and forces had to be found which would automatically deliver the airplane at the end of the run possessed of an angular acceleration that would help the pilot during the first few critical seconds after the take-off.

The problem was set up for solution on an IBM Card Programmed Calculator, fortunately equipped with two storage banks. The procedures involved have been described in detail in a published paper by John Lowe,[4] supervisor of Computing Engineering at the Santa Monica Douglas Aircraft plant. Investigating the effect of changes in the location of the catapulting force, the characteristics of the shock absorbing systems, the physical location of the landing gear, different wind speeds over the deck, and other factors, made it necessary to carry out that pro-

cedure some 55 times. The design features that were incorporated in the airplane as a result of these calculations were checked against flight tests carried out by the Navy, and the results were in excellent agreement.

To describe a really full-scale use of an adequate computing facility in a large engineering effort, it would be necessary to multiply such situations as just described by perhaps several hundred times. These are fed into the computing facility from a number of engineering specialty groups. The computing facility finds itself taking them all on at once like a master chess player carrying on many games simultaneously: moving from one to another continually but returning periodically to the later developments of each problem in turn. Douglas operations to date are very very far from such a scale. Fortunately, they have had 6 years to come as far as they have. It is felt this preparation was very important for the effective use of the relatively tremendous power of the equipment to be available by the end of 1952. How far that equipment will take Douglas towards experiencing such a vast increase in the number of problems that can be dealt with, cannot be surmised. However, it is very seriously doubted whether it will then be possible to do all that the company would like to be able to do. The reason for that, as you can see, lies entirely in the fact that for some years to come the concern in realizing full utility from big machines will not be in solving a few big problems but will be in the more agile handling of enormous numbers of problems. Some of them will be larger, some smaller, than those discussed here, but on the average of about that order.

SOME MACHINE DESIGN OBJECTIVES

The design of any machine is a matter of compromise and balance of its functions for the purpose intended. No doubt this balance has been earnestly sought in the design of all big computing machines. Almost everything that has been said has been calculated to show the importance, to such users as the aircraft industry, of really flexible input and output equipment. It seems to me that most of the machines available are much cleverer in their internal operating philosophy than they are in their input and output devices. With aircraft, normal usage clearly requires many repetitions of a given procedure, each time with changes in some of the initial parameters. It is typically found on examination that nine times out of ten there is no further interest in the results, but another computation must be made. It must be possible to remove completely the problem from, and later return it to, the machines. In such a case, obviously the design balance has to be shifted to a much heavier emphasis on the input and output equipment.

The input equipment and coding need not necessarily be simple, though that would be ideal. However, it should be possible to perform these operations without monopolizing the computer itself. Obviously, mechanization of the coding process by coding machines, such as those Dr. Aiken has been developing, is very much to the point. In the case of the output equipment the same sort of reasoning applies. Permanent records of most calculations will not be required, but the results are wanted promptly. Some device that permits scanning of selected values from the internal storage, such as recently has been done on a display cathode-ray tube on Project Whirlwind, is excellent. Then it is possible to examine the effects of the last change, and either determine what to change next, or decide that the results are satisfactory and obtain a permanent record of them. Alternatively, it should be possible to take that problem completely off the machine to allow time to study what to do next. If the machine has a printer output it should be possible to free the main machine by clearing its storage into an auxiliary storage and printing out from there. However, it ordinarily should not be necessary to do that to find out what is in the storage.

CONCLUSION

In conclusion, aeronautical engineering use of computing machinery has progressively increased in scope and magnitude during these past 6 years. At the beginning of that period, machine methods were applied on a very modest scale. It was done in the hope that it would be the eventual means of breaking the major design bottleneck, the ever-growing volume of mathematical investigation demanded by modern aircraft. Machine computing has been at least partially successful in accomplishing that purpose. The scale of these operations has grown naturally from its tentative beginnings to the point that machine computing is definitely indispensable now. It is becoming increasingly vital at a startling rate.

Computing machines are themselves an engineering product. It is entirely likely that, in their ultimate development, the engineering profession itself will be the biggest user of that product.

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Radioactivity Tests Radar Coatings

Scientists are using radioactivity to measure 0.0001-inch coatings of silver on radar with accuracy up to 10 millionths of an inch. The new method, developed at Armour Research Foundation, is faster and cheaper than conventional microscopic tests.

Thin coatings of silver of a required thickness and uniformity insulate brass radar waveguides. In the new method, waveguides are bombarded with radioactive radium-berylium. Radioactive isotopes of silver are formed and resulting radiation is measured by Geiger counters, affording a highly accurate picture of plating thickness. The process takes about 5 minutes and does not destroy the waveguide used for measurement.

Signal Component Control

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THE PROPOSED AIEE SYMBOLS and definitions for feedback control systems are employed. The term "signal component control" (scc), is used to designate the control method, and the term "scc device" to specify the particular associated equipment. The primary objective of the method is to shape the reference input so either the indirectly or the directly controlled variable, as may be elected, will be nearly identical at all times to the command signal. It is intended to achieve this objective so that: 1. The controlled variable will contain, at all times, a component which is identical to the command signal. 2. In a very short time (usually this will be made less than one-half the longest natural period of oscillation of the control system), all aperiodic deviations of the controlled variable from the command signal will be reduced to zero. 3. In the same short time each natural mode of the control system will be reduced to zero.

A second objective might be to make the controlled variable follow a derivative of the command function. It is possible to realize this and other objectives, but only the primary one is discussed here.

Assume for a step command signal the system response is

$$q(t)=A_0+\sum_{1}^{n}A_k\epsilon^{\xi_k t} \tag{1}$$

where t=time; the A_0, k, and n are real numbers; and A_k and ξ_k may be real or complex (if complex, appearing in conjugate pairs). Next, suppose the command signal over brief intervals of time (such as those mentioned) could be approximated by

$$v(t)=M_a+M_bt \tag{2}$$

where M_a and M_b are real numbers. The system response becomes

$$q(t)=A_0[M_a+M_bt]-M_b\sum^{n}\frac{A_k}{\xi_k}+\sum^{n}A_k\left[M_a+\frac{M_b}{\xi_k}\right]\epsilon^{\xi_k t} \tag{3}$$

Assume that the following may be achieved with the scc device:

1. The command signal, $v(t)$, may be delayed by the discrete amounts of time T_1, T_2, ..., T_{n+l} where, $0<T_1<T_2<\ldots<T_{n+l}$ (where l is an integer).

2. At the corresponding instants of time, the command, $v(t)$, and the delayed forms may be multiplied by the constant positive or negative real numbers B_0, B_1, B_2, ..., B_{n+l}, respectively, summed, and applied to the control system.

Digest of paper 52-211, "Signal Component Control," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Technical Operations Committee for presentation at the AIEE Fall General Meeting, New Orleans, La., October 13–17, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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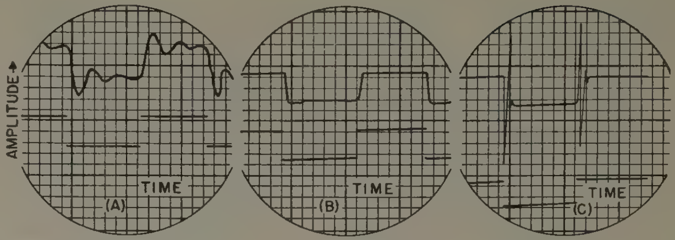

Figure 1. Response of a 2-mode oscillatory control system to a step command signal. All lower curves are commands; upper curves of A and B show controlled variable without and with signal component control, respectively. Upper curve of C is reference input for case B where scc device is used

Then the response of the control system for $t>T_{n+l}$ is

$$\left.\begin{aligned}
&q(t)=A_0[M_a+M_bt][B_0+B_1+B_2+\ldots+B_{n+l}]-\\
&\quad M_b\left\{\left(\sum_{1}^{n}\frac{A_k}{\xi_k}\right)B_0+\left(A_0T_1+\sum_{1}^{n}\frac{A_k}{\xi_k}\right)B_1+\ldots+\right.\\
&\quad \left.\left(A_0T_{n+l}+\sum_{1}^{n}\frac{A_k}{\xi_k}\right)B_{n+l}\right\}+A_1\left[M_a+\frac{M_b}{\xi_1}\right]\epsilon^{\xi_1 t}\{B_0+\\
&\quad \epsilon^{-\xi_1T_1}B_1+\ldots+\epsilon^{-\xi_nT_{n+l}}B_{n+l}\}+\ldots\\
&\quad A_n\left[M_a+\frac{M_b}{\xi_n}\right]\epsilon^{\xi_n t}\{B_0+\epsilon^{-\xi_nT_1}B_1+\ldots+\epsilon^{-\xi_nT_{n+l}}B_{n+l}\}
\end{aligned}\right\} \tag{4}$$

Since in equation 4 the B and the T values may be varied within broad limits, it is elected to make the first line equal M_a+M_bt, and each term bracketed, {}, equal to zero. Accordingly, where it is assumed that $A_0\neq 0$

$$\left.\begin{aligned}
&B_0+B_1+B_2+\ldots+B_{n+l}=\frac{1}{A_0}\\
&T_1B_1+T_2B_2+\ldots+T_{n+l}B_{n+l}=\frac{1}{A_0^2}\sum_{1}^{n}\frac{A_k}{\xi_k}\\
&B_0+\epsilon^{-\xi_1T_1}B_1+\epsilon^{-\xi_1T_2}B_2+\ldots\epsilon^{-\xi_1T_{n+l}}B_{n+l}=0\\
&\quad\vdots\\
&B_0+\epsilon^{-\xi_nT_1}B_1+\epsilon^{-\xi_nT_2}B_2+\ldots+\epsilon^{-\xi_nT_{n+l}}B_{n+l}=0
\end{aligned}\right\} \tag{5}$$

The B and T values, determined from equations 5, define a set of signal components which, when employed in the design of the scc device, permit the primary objective to be achieved. It is quite important that while equations 5 are influenced by the form chosen for $v(t)$, the magnitudes of the coefficients in $v(t)$ and the independent variable, t, no longer appear.

The kind of results which may be expected from the use of signal component control method are illustrated by the simple example in Figure 1.

Transformers for New Switchgear Testing Laboratory

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MEMBER AIEE

FOR HIGH-VOLTAGE short-circuit testing of circuit breakers, fuses, disconnect switches, and so forth, at the new high-capacity Switchgear Testing Laboratory of the General Electric Company, Philadelphia, Pa., two 1,100,000-kva short-circuit transformers were installed.

Each transformer is rated single phase; 60 cycles per second; 7,750/15,500 volts to 220/381Y kv with taps in the high-voltage winding for 38/72.5/84/140 kv, and the corresponding Y voltages; 100,000 kva nominal; 1,100,000 kva short circuit. The short-circuit duty consists of 15 short circuits, each of 10 cycles duration, within 1 hour followed by normal excitation for 4 hours. Initial current, symmetrical component of which having rms value corresponding to 1,100,000 kva and normal voltage, completely offset.

The operating requirements led to a design which differs from that of a normal power transformer of comparable physical size and voltage rating. Whereas a normal power transformer, in its entire lifetime is subjected to a comparatively few accidental short circuits at random points on the voltage wave, the subject transformer is used exclusively for short-circuit testing. Many times a year it is deliberately short-circuited at a point on the voltage wave selected to give maximum offset of current and with a minimum of impedance in the circuit, which results in high short-circuit currents. Therefore, paramount consideration in the design was that it have adequate mechanical strength to withstand the abnormally high short-circuit forces. The fact that the transformer has no continuous rating actually simplified the design by making cooling ducts through the windings unnecessary, thereby allowing a more solid and compact structure.

Figure 1. Transformer in final stages of assembly at factory

The design consists of a concentric arrangement of circular coils on a 2-legged core. The low-voltage winding, placed next to the core leg, is helical with no oil ducts either axially or radially. The high-voltage winding consists of six concentric cylindrical layers connected in series, with taps taken from the ends of the various layers to bushings located on the cover. There are no oil ducts in the high-voltage winding. Among the unusual features of the design are

1. Steel supporting cylinder, with insulated joint, to prevent the low-voltage windings being crushed by inwardly directed radial forces of very high magnitude.
2. Steel supporting rings at the ends of all high-voltage winding layers and at the ends of the low-voltage coils to support the windings against axial short-circuit forces.
3. Extremely rugged winding clamps arranged for adjusting clamping pressures on high-voltage and low-voltage windings independently of one another. The adjustable clamps cover the complete circumference of the coils. They can be adjusted through manholes in the cover.
4. Shields between all adjacent layers of the high-voltage winding. This is desirable because, at various times, each of the taps act as a line lead, allowing voltage surges to enter the winding at any of these points.

Pertinent physical and electrical characteristics are

Weights:

When untanking	234,000 pounds
Tank and fittings	87,000 "
Oil, 23,000 gallons	171,000 "
Total	492,000 pounds

Dimensions:

Floor space, approximately 24 by 17 feet.
Height over-all, 36 feet.

Tested impedances, at 100,000-kva base:

15,500 to 220,000 volts	7.63 per cent
15,500 to 38,000 volts	2.99 per cent

With intermediate values on other tap connections.

There are no radiators or other heat exchangers. A remotely located oil conservator serves the two transformers which have been installed. Figure 1 shows transformer in final stages of assembly at the factory.

Digest of paper **52-190**, "1,100,000-Kva Short-Circuit Transformer in the New High-Capacity Switchgear Testing Laboratory," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23-27, 1952. Not scheduled for publication in AIEE *Transactions*.

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New Rectifier Tube for Extremely High Power and Voltage Levels

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This new tube is identical in major dimensions to the original "Kenotron" as well as a later improved version. Thus it is easily adapted to many existing installations and facilitates the design of new apparatus to utilize fully its greater capabilities.

THE RECTIFICATION of alternating currents at high voltage by means of high-vacuum thermionic diodes has been common practice for many years. Dushman's "Kenotron," first described in 1915, was one of the earliest examples of this application of electronics. Since that time, high-vacuum high-voltage rectifier tubes have come into general use for a number of applications, notably X-ray apparatus, electrostatic particle-precipitation, and high-voltage cable testing.

In all such applications, the voltage requirements are extremely high, that is 30 to 200 kv or higher, while the current requirements are relatively low, being generally less than 1 ampere. Hence the total power output of such rectification units is relatively quite low, in comparison with the power output obtainable with mercury-arc rectifiers or gas-filled tubes. However, the practical voltage limitation for high-powered gas-filled types lies at approximately 20 kv.

For a number of years, the maximum power requirements for applications of rectified high voltage exceeding the voltage limit of gas-filled rectifiers could be handled adequately by the well-known Kenotron illustrated in Figure 1. It has a maximum voltage rating of 150,000 volts and a peak current rating of 750 milliamperes, and, until recently, was the only type of tube available for relatively heavy-duty applications in the high-voltage range. With the advent of large-scale isotope separation by means of mass spectrometers, however, the need for greater and greater d-c power outputs at higher voltages continued to arise, leading to the development of two new tube types having the general form of the Kenotron, but with lower plate-circuit power losses, and peak current ratings up to 2.5 amperes. Subsequently, other new applications have arisen which require still higher current and power levels and place still greater demands on the high-voltage rectifier tubes.

For example, a long-range radar application requires a power supply unit capable of delivering a continuous current of 3.5 amperes at 100 kv. In another case, a high-efficiency particle-precipitation unit for catalyst recovery requires a hold-off diode to pass current pulses of 10 amperes peak, 0.4 ampere average, and to hold off 100 kv. Further evolution of the development referred to has made it possible to produce a tube capable of meeting such requirements. This article discusses the factors which limit the use of high-vacuum rectifiers for high-current applications and describes the new design principles which have been evolved to raise these limits sufficiently to meet the requirements of these high-current high-voltage devices.

HIGH-VACUUM RECTIFIER FUNDAMENTALS

IT WILL BE helpful to review the fundamentals of high-vacuum thermionic rectifier operation before considering the various design factors to be discussed. In its essentials such a rectifier is the simplest form of thermionic vacuum tube, being a diode with an electron-emitting cathode and a nonemitting anode. The first form in which this type of tube appeared was the original "Fleming valve." Its application to the rectification of high-voltage alternating currents was described by Dushman[1] in 1915. Its rectifying action depends on the fact that current may flow through it in the direction represented by the passage

Figure 1. A familiar type of high-voltage rectifier tube

Full text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952.

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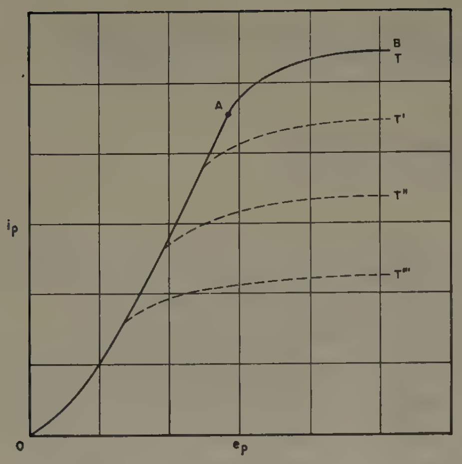

Figure 2. General form of diode characteristic

of electrons from the cathode to anode, but cannot flow through it in the opposite direction.

The cathode consists of some form of thermionic emitter with provisions for heating it to temperatures for electron emission in accordance with Richardson's[2] well-known equation. In high-voltage tubes it usually takes the form of a filament which is heated by current flowing through it. The anode member provides a conducting surface suitably positioned with reference to the filament to receive electrons from it. Electrons will flow from the filament to the anode when the latter is sufficiently positive with respect to the former to overcome the space-charge effect of the electrons emitted by the filament. The amount of current which can flow is a function of the potential difference between cathode and anode as given, in accordance with the 3/2-power law,[3] by the equation

$$i = ke^{3/2}$$

where i is the current, e is the potential difference, and k depends on the system of units and the geometry and dimensions of the electrodes and the interelectrode spacing. The general form of this relationship is illustrated by the curve OA of Figure 2.

When the tube is operating as a rectifier, the current through it is determined, not by the current-carrying capacity of the tube itself, but by the resistance (or impedance) of the load which is supplied by the rectifier circuit. Figure 3 shows such a rectifier circuit in its simplest form. The peak circuit voltage E_m is always much greater than the anode-to-cathode voltage drop e_p necessary to cause the electron current I_m to flow through the tube, so that I_m will be approximately equal to E_m/R_L. Rectifier tubes are usually designed and rated on the basis that I_m will not exceed a value of i_p corresponding to point A in Figure 2, so that the tube will always operate in the so-called "space-charge-limited region," where the 3/2-power law applies to the interelectrode current and voltage. Otherwise, the tube may be forced to operate in the "emission-limited region," where the voltage drop no longer will be a simple function of the current but will vary very widely with slight variations in both I_m and filament temperature, and generally unsatisfactory performance will be obtained.

When the alternating voltage reverses in polarity, the anode becomes negative with respect to the cathode and under this condition no current can flow through the tube or the circuit which it controls. Hence the entire voltage $-E_m$ will appear across the tube. The design and construction of the tube give it a "maximum inverse voltage" rating, limiting the maximum value of voltage which it may be used to rectify.

Although the "forward voltage drop" through the tube during the conducting half-cycle is usually negligibly low in comparison with the total voltage of the circuit, it nevertheless has a finite value which results in a loss of power from the circuit. This loss shows up as heat in the anode when the electrons falling on it give up the kinetic energy which they acquire due to the interelectrode voltage drop. The instantaneous value of power represented by this energy dissipation is equal to the instantaneous product of i_p and e_p. In order for the tube to function as a practical rectifier, its anode structure must be capable not only of absorbing this maximum instantaneous power but also of dissipating energy at the average rate of power input to which it will be subjected. The average power absorbed by the anode is the average value of the e_pi_p product integrated on a continuous basis.

The average anode power can be calculated from the e_p-i_p curve, provided the waveform as well as the average or peak value of the current flowing through the tube is known. If the current waveform cannot be established by mathematical analysis on the basis of known circuit constants, an accurate calculation of the average power can be made by means of a graphical approach if an accurate current-time graph can be obtained by some suitable oscilloscopic viewing procedure. An illustration of this method of determining the anode power dissipating requirement is given in Figure 4, wherein a complex current waveform, such as would be obtained in a half-wave rectified circuit supplying power to an X-ray tube, is treated.

This graphical procedure has the advantage of being completely general, in that it is applicable regardless of the complexity of the waveform and regardless of the shape of the e_p-i_p curve, which may be such as not to lend itself to algebraic solutions. For instance, in some types of tubes the e_p-i_p curve may depart appreciably from a 3/2-power function, but if a graph of the actual function is given its algebraic expression is not required. For simpler waveforms readily expressible analytically, algebraic solutions may be feasible and much less laborious. For example, when the current flow through the tube takes a simple square-wave form, as in the common case of a bridge-type rectifier circuit supplying a load through an inductance-input type of filter, the calculation becomes

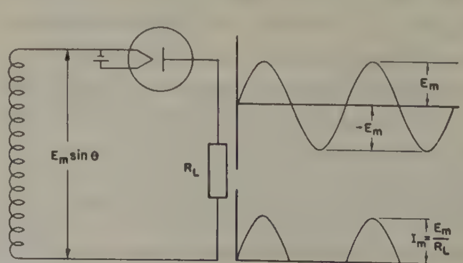

Figure 3. Simple rectifier circuit providing half-wave rectification

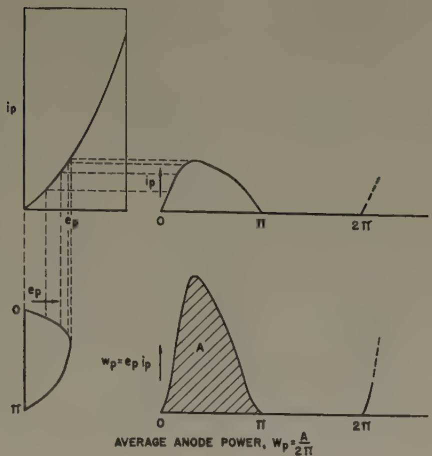

Figure 4. Graphical calculation of anode power dissipation from current waveform and e_p—i_p characteristic of rectifier tube

extremely simple, as shown in Figure 5. When the rectifier circuit supplies a pure resistance load, the tube current waveform becomes a simple half-sine-wave (assuming sine-wave voltage, and e_p negligibly small compared with E_m). In this case, if the $e_p - i_p$ curve takes the usual form $i_p = ke_p^{3/2}$, an equation can be derived for the average anode power as follows:

$$W_p = \frac{0.27}{k^{2/3}} I_m^{5/3}$$

DESIGN PROBLEMS FOR SIMULTANEOUS HIGH VOLTAGE AND HIGH POWER

From the foregoing discussion, it is apparent that the difficulties associated with the design of high-vacuum rectifiers fall in three categories, namely, those having to do with the following factors: 1. Cathode emission requirements. 2. Inverse voltage rating. 3. Anode power dissipation.

These factors are not entirely independent of each other, but are interdependent in some respects. For example, in order to obtain high emission with an economical consumption of cathode heating power, it is desirable to use an oxide-coated cathode. However, in the present state of the art this type of cathode is not feasible for use in tubes for the high-voltage ranges being considered, for various reasons including the inability of the coating to withstand the high electrostatic forces. Hence, for voltages higher than about 20 kv, the cathode usually takes the form of a directly heated tungsten filament. The design of tungsten filaments is based on known factors which relate wire length and diameter to corresponding volt-ampere characteristics and to operating temperature, emission, evaporation rate, and life. Design data for pure tungsten filaments are often based on the tables of Jones and Langmuir.[4] A satisfactory design procedure is also given by Espe and Knoll.[5] Thoriated tungsten filaments, which can be operated at considerably lower temperature and hence require much less power for heating, may be satisfactorily employed under proper circumstances. A design procedure for such filaments has been published by Dailey.[6]

"Design" as used in the preceding paragraph refers only to the electrical design to control the volt-ampere and emission characteristics. Certain mechanical properties are also necessary, because of the extremely high "inverse voltage" which appears across the tube. In the first place, the insulating envelope of the tube must be designed so as to be capable of withstanding the maximum rated voltage. Many factors enter into this design, including consideration of whether it is to operate in air or in some high-dielectric-strength insulating medium such as oil or compressed gas. The spacing between the electrodes must be relatively large; the necessary spacing increases exponentially with the voltage, but is independent of the peak current rating. The most important mechanical aspect of cathode design results from the electrostatic force between anode and cathode, which increases with the square of the voltage. At the high voltages under consideration, even with the relatively large distance required between electrodes, this force becomes so great that the mechanically weak incandescent filament cannot withstand the pull without distortion unless its configuration is such as to cause the force to be resolved into a stress having a component only along the length of the filament and none at right angles, or unless the filament can be shielded in such a way as to remove most of the voltage gradient therefrom and thus reduce the distorting force to a negligible value.

The two methods of overcoming this electrostatic force problem which have been in common use for many years have been described by Gross and Atlee.[7] The first, based on the alternative of giving the filament a stable configuration which will resist the force without distortion, consists of loops projecting toward a planar anode. The other uses a helical filament within a concentric cylindrical anode and employs the second alternative of shielding the filament from the potential gradient, by means of a coarse helix of heavy wire interposed between the filament and anode surface. Both types have been satisfactory in the usual applications for which such tubes have been designed.

As long as the rectifier is to be used at low current levels the problem of anode power dissipation capacity does not become significant. As mentioned in the preceding section, the power absorbed by the anode is equal to the time integral of the e_p i_p product, and since e_p generally will be proportional to $i_p^{2/3}$, the power is proportional to $i_p^{5/3}$. Thus the anode power dissipation factor increases exponentially with the anode current, with fixed tube geometry, so that for high-powered applications where higher peak and average current values are required, this factor becomes one of the most important of the design problems. A concrete example will now be introduced

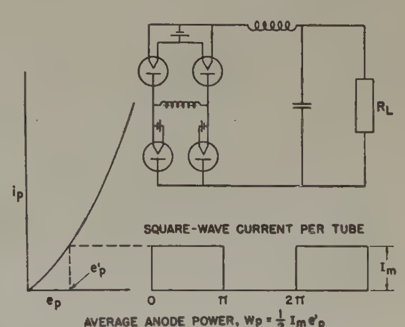

Figure 5. Calculation of anode power dissipation for square-wave current through rectifier tubes

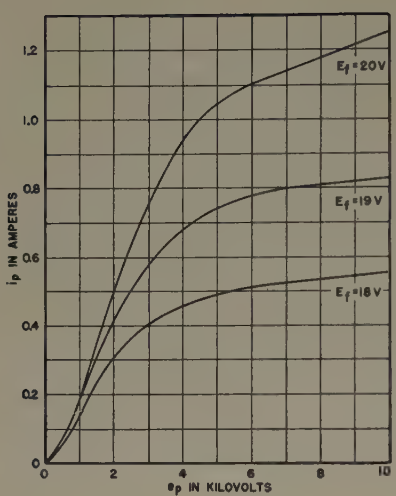

Figure 6. $e_p - i_p$ **characteristics of conventional high-voltage rectifier tube**

to show how this factor may constitute the limitation on the power output of a rectifier circuit.

The Kenotron shown in Figure 1 has ratings of 150-kv inverse voltage, 0.75-ampere peak anode current, and 750-watt anode dissipation. Its $e_p - i_p$ curves are given in Figure 6. If tubes of this sort are used in a bridge-type circuit supplying an inductance-input type of filter as shown in Figure 5, with a 0.75-ampere load, the peak current through each tube will be 0.75 ampere, and the waveform will be a square wave of 1/2-cycle duration. The voltage drop through the tube at 0.75 ampere is 3,000 volts, so that the peak power in the anode is 2,250 watts, which for the square waveform represents an average of 1,125 watts absorbed by the anode and is therefore in excess of the rated anode dissipation. It will be seen that the maximum current load that can be handled on this basis is 0.62 ampere, which corresponds to a drop of 2,420 volts, giving 1,500 watts peak or 750 watts average power. Hence, its maximum power output limit is imposed, not by its cathode emission limit which would permit a 0.75-ampere load, but by its anode dissipation rating which limits the maximum load to 0.62 ampere.

DESIGNING FOR HIGHER POWERS

One, perhaps the most obvious, approach to designing a tube for higher values of average load current would be to design the anode for greater power dissipating capacity. Another approach was suggested by the fact that the anode power is proportional to the voltage drop, e_p. Thus any reduction in e_p for the given peak i_p would result in a proportionate decrease in the power which must be dissipated by the anode. Hence, a higher average current rating could be achieved with the same anode dissipation rating if it should be possible to reduce the forward voltage drop by changing the geometry of the anode-cathode relationship and still maintain the ability to meet the requirements of high inverse voltage.

As mentioned previously, the cathode design must be such that the electrostatic force concomitant with high inverse voltage will not distort or break the incandescent tungsten filament. In the tube whose characteristics are given by Figure 6, the filament is a small-diameter spiral concentric with a cylindrical anode and is shielded from the high field by a surrounding coarse helix of heavy wire as illustrated in Figure 7. A study of the interelectrode geometry and its relationship to the forward voltage drop indicates that the shielding helix also reduces the gradient at the filament during the conducting half-cycle and thus necessitates a higher total forward voltage than would be required if the shield could be omitted. Tests and experience indicate that a spiral filament of this type will not remain stably fixed concentric with the cylinder under high inverse voltage conditions without such shielding. Hence, the possibility of utilizing a configuration such as to cause the force to be resolved into a stress having only a component along the length of the filament was investigated. The conventional form of this type of filament structure employed for many years, consisting of loops projecting toward a planar anode, while generally providing lower drop than the cylindrical construction with shielded filament, does not lend itself very advantageously to high power requirements because the planar anode provides less radiating surface. Eventually an entirely new form of cathode, based on a geometrical arrangement proposed by Skehan and Magnusson,[8] was developed which, in conjunction with a cylindrical anode, provides minimum forward voltage drop and maximum resistance to the electrostatic pull. This design was evolved in accordance with the following line of reasoning.

The voltage required to produce a given flow of space current from a filament to an anode will be at a minimum when the entire length of the filament is spaced equidistantly from the anode surface, this spacing being dictated by the inverse voltage requirements with reference to maximum potential gradient allowable for electrical reasons. These conditions would be met if the filament consisted of a number of parallel strands arranged in a cylindrical grouping within and concentric with the anode cylinder. Upon application of the high voltage, however, the electrostatic pull on each strand of such a filament structure would be resolved into a lengthwise stress of great magnitude unless the strand were permitted to "bow" considerably toward the anode surface, thus destroying the desired condition that the filament be equally spaced from the surface throughout its length. To overcome this difficulty, the individual strands can be

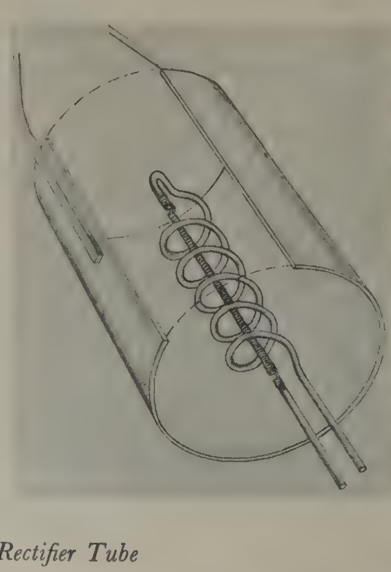

Figure 7. Conventional high-voltage rectifier-tube cathode construction

made to spiral part way around the cylindrical configura-tion defined by the cathode structure and thus they will have sufficient "bow" toward the anode to resolve the electrostatic pull into a tangential stress of greatly reduced magnitude and yet be equidistant from the anode surface throughout their entire length. The length of each strand is adjusted so that it is of the correct length to conform to this configuration when heated to operating temperature.

A complete filament structure according to the new design is shown in Figure 8. The tube employing this filament, having inverse voltage, peak anode current, anode dissipation, and filament current and voltage rating similar to those of the Kenotron in the example referred to, has e_p-i_p characteristics as shown in Figure 9. Apply-ing a similar example, the voltage drop at the peak anode current rating of 1 ampere is 500 volts, which for the square waveform represents an average of 250 watts absorbed by the anode. Thus the anode dissipation rating no longer imposes the limitation on the load current which such a rectifier can be called upon to supply.

The enormous decrease in anode power dissipation re-quired for a given load brought about by this new type of cathode structure indicates the possibility of designing such tubes for greater load ratings simply by providing more cathode emission. The cathode characteristics of the original tube are as follows: Filament current of 24 amperes at 20 volts or 480 watts, provides a usable emission of 1.0 ampere. This type of cathode, which is a pure tungsten filament, thus would require approximately 4,800 watts of filament power to provide a peak current rating of 10 amperes, which is the requirement dictated by the proposed application. Not only would it be in-feasible to construct a cathode structure for such filament power in a tube structure of this size, but the dissipation of this power would in itself overheat the cylindrical anode surrounding it. Hence, the possibility of obtaining the required value of emission current with very much less cathode power by utilizing a much more efficient type of emitter was made the subject of a very thorough investi-gation.

Thoriated tungsten appeared to be a promising possi-bility for two reasons: 1. its efficiency as an emitter is such that the required usable emission of 10 amperes

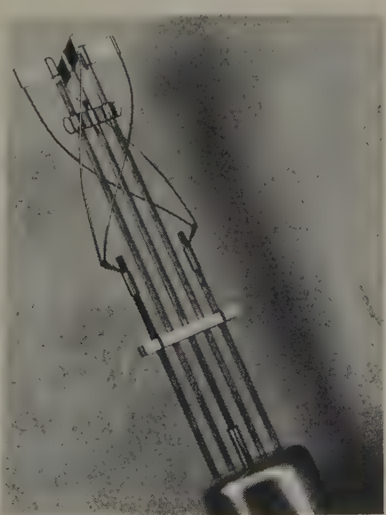

Figure 8. New type of cathode for improved performance in high-voltage rectifiers

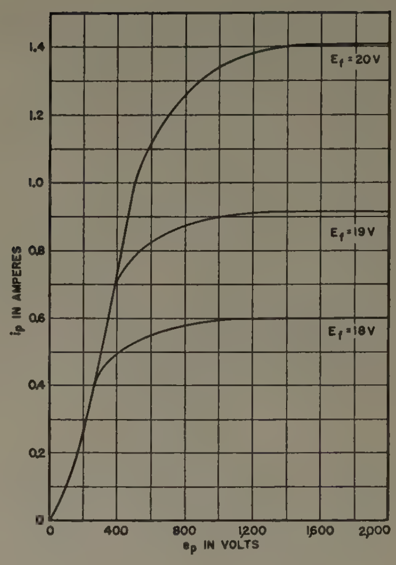

Figure 9. e_p-i_p characteristics of new-type rectifier tube with pure tungsten filament

could be expected to be obtained with filament power of about 250 watts; 2. it could be adapted readily to the catenary-type filament structure previously described. Thoriated filaments had not generally been used in tubes rated for more than a few thousand volts.[9] Reasons generally ascribed for their unsuitability in high-voltage tubes are their inability to withstand the mechanical stresses due to high electrostatic fields, the danger of de-activation by positive ion bombardment, and other effects of residual gas.[10] During the war, some tubes were made with thoriated filaments for operation at 35 to 40 kv, but the step to 100 kv could not conservatively be made without thorough analysis of the known hazards and means for their circumvention, and of course adequate experimental confirmation of any proposed design.

The catenary configuration of the filament already described so minimized the mechanical stresses that no difficulty was expected from this source in connection with the proposed use of a thoriated filament in a 10-ampere 100-kv rectifier tube. It also appeared likely that the other major hazard, deactivation by positive ion bom-bardment, would be circumvented by a combination of two factors: 1. the fact that the forward voltage drop, which is the only voltage component which can accelerate positive ions toward the cathode, is made unusually low by the interelectrode geometry and thus the energy of the bom-barding ions would be minimized; and 2. the amount of residual gas present would be reduced to a tolerable level by employing X-ray tube production techniques in the processing of parts and on final exhaust of the completed tube.

The tube as actually constructed, with a thoriated tungsten filament operating at optimum temperature with 250 watts of filament power, results in an e_p-i_p character-istic as shown in Figure 10. It is apparent that the avail-able emission is adequate to meet the 10-ampere peak current requirement. The plate wattage dissipation re-quired under the assumed conditions of square current pulses of 10 amperes amplitude at a duty cycle giving an average current of 0.4 ampere is readily computed as follows: Voltage drop at 10 amperes is 2,500 volts, hence

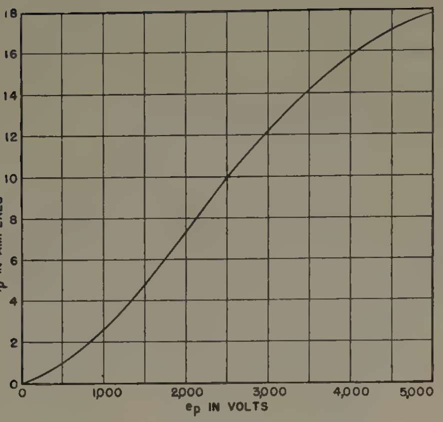

Figure 10. e_p—i_p **characteristic of new-type rectifier tube with thoriated tungsten filament**

the peak plate power is 25,000 watts. Since the duty cycle is 0.04, the average plate circuit power absorbed by the plate is 1,000 watts. Inasmuch as the plate dissipation of the original tube with a 480-watt filament was 750 watts, the same plate with approximately 250 watts less of filament power radiating to it therefore can handle the required 1,000 watts of plate power.

For the application requiring a continuous current output of 3.5 amperes, a 3-phase bridge circuit employing

Figure 11. The new rectifier tubes: (left) with thoriated tungsten filament; (right) with pure tungsten filament

six tubes, with choke-input filter, will draw a square current wave form of 3.5 amperes peak value with a duration of 1/3 cycle per cycle through each tube. The plate wattage dissipation requirement is computed as follows: Voltage drop at 3.5 amperes is 1,200 volts; peak plate power, 4,200 watts; average plate power, 1,400 watts.

Inasmuch as 1,000 watts is obtainable from the plain tantalum cylinder, it proved to be a relatively simple matter to increase its radiation rate by approximately 50 per cent by any one of various expedients, such as treating the outer surface of the cylinder with a coating of tungsten powder sintered thereon prior to assembly into the tube envelope. In its final form, the tube carries a plate dissipation rating of 1,500 watts, a peak emission rating of 10 amperes, an $e_p - i_p$ characteristic per Figure 10, and a maximum inverse voltage rating of 110 peak kilovolts. Such ratings permit a current output from a 3-phase power supply unit of 3.6 amperes at 100 kv, or a power output of 360 kw. A prolonged period of life testing and limited field tests have given favorable indications of the mechanical and also electrical ruggedness of the design, and a number of installations are now going into routine service for applications such as those described.

The tube is identical in major dimensions to the original Kenotron as well as the improved 1-ampere version, and does not differ greatly in appearance. See Figure 11. Its interchangeability with the older types makes it readily adaptable to many existing installations and simplifies the design of new apparatus to utilize its maximum capabilities.

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Electronic Train Signal

A new system of automatically identifying approaching trains promises to speed up the railroad job of routing heavy traffic through complex switching areas. The system was described in a report presented at the meeting of the Signal Section of the Association of American Railroads.

Essentially electronic in nature, the system allows a train to flash ahead to interlocking operators its class and destination far more quickly and positively than by present means. Equipment consists of a coil mounted on a train that will set up a reaction in a similar coil mounted between the tracks, thus identifying the train according to the frequency of its tuned loop. Train identity can be changed merely by changing the loop on the train to one of a different frequency. The report said the device can identify conclusively even the fastest moving trains.

A use foreseen for the system would be to have interlocking controls in terminals set up in such a manner that an approaching train, in identifying itself, also would line up automatically its own route through a yard.

Recorder for Platinum Resistance Thermometer

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MEMBER AIEE

THE PLATINUM resistance thermometer is the accepted interpolating device for the 1948 International Temperature Scale from −182.97 degrees centigrade to +630.5 degrees centigrade. When properly made, the reproducibility of its resistance justifies its calibration and use for measurements to 0.01 degree centigrade, or 1/80,000th of its temperature range. E. F. Mueller attacked this difficult resistance measurement problem with a hand-operated multiple-decade bridge.[1] D. R. Stull attacked the problem with a mechanically balanced recorder using a slide-wire plus decades,[2] and used the recorder for the determination of chemical purity by freezing point measurement. While Stull was building his recorder, the author and his associates also were building a recorder (using one of the several methods of electronic balancing which had then been developed). Based on the experience with these two types of recorders there was developed a third type, with improved precision, the experimental form of which is the subject of this article.

The recorder has a slide-wire with a span of 1.02 ohms. It also has a 1-ohm decade and a 10-ohm decade which automatically are switched to give a total range to the recorder of 0–100 ohms. Features are included in the recorder which permit its unattended operation with a precision approaching 0.001 ohm which corresponds approximately to 0.01 degree centigrade for a 25-ohm platinum thermometer.

Figure 1, which is the bridge circuit, shows the main slide-wire at the left, the 1-ohm decade at the lower right, and the 10-ohm decade just above it.

When the resistance of the thermometer changes in response to a change in temperature the unbalance in the bridge is detected by the electronic amplifier marked *DET* which, through a motor, drives the slide-wire contact towards the balance point. A pen moved with the contact makes a continuous record on a 10-inch strip chart. If the change in thermometer resistance is sufficient to drive the pen to the limit of its travel, a switch is tripped which starts the motor that drives the 1-ohm decade directly. This same motor drives the 10-ohm decade, if required, through a Geneva movement. Print wheels for the two decades periodically print two figures on the left margin of the strip chart.

Since the pen mark may be read to three figures, a total of five figures may be read from the chart. In order that the fifth figure should have significance, special design and construction was required at several points.

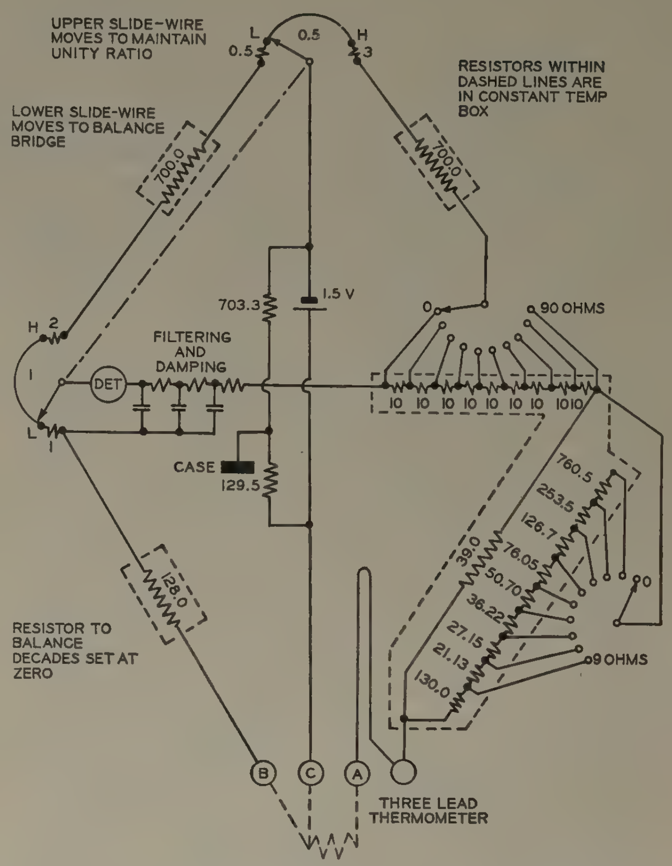

Figure 1. Bridge circuit. The thermometer being in the same arm as the decades, a substitution type of measurement is made

To avoid errors from expansion of the chart, such as from increase of humidity, an improved form of compensating mechanism had to be built.

The balancing amplifier had to be built with high gain and zero-offset small compared to the 2 microvolts corresponding to the fifth figure (0.001 ohm).

The principal resistors had to be thermostated and because of the normal temperature rise within the recorder case it was necessary to thermostat at 55 degrees centigrade. This required that the critical resistors have their minimum temperature dependence in the region of 55 degrees centigrade by making each one partly of manganin and partly of copper in series combination.

Digest of paper 52-157, "Electronic Recorder With Range and Precision Adequate for the Platinum Resistance Thermometer," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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The author wishes to give credit to D. R. Stull, who with his associates at the Dow Chemical Company, pointed out the need for an instrument of this general type, and to acknowledge the many significant contributions of the late F. F. Dern, Jr.

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Application of Power-Line Carrier by Analogue Computer Studies

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Conditions previously ignored and ways of measuring the characteristics of the coupling networks, associated traps, and the adjacent power equipment of the proposed channel can be handled rapidly by the analogue computer before the installation is made.

THE characteristics of power-line carrier channels can be accurately predicted if an analogue computer study is made of critical portions of the power system to be used for the carrier channels. In the past, many carrier channels have failed to perform as well as semiempirical calculations have indicated they would. Since these semiempirical calculations of carrier channels worked with fair accuracy in many installations, it was felt that when the calculations did not yield the same results as the final installation, it was "just one of those things." One of the best ways to prevent this happening is to make an analogue computer study of the power system.

The methods normally used for carrier calculations are quite simple. Basically, it is assumed that power-line carrier transmitters have some fixed output. A given attenuation is introduced when the output is coupled to a transmission line through a coupling network. The signal may divide among several possible paths at the coupling point causing an added loss in signal strength in the desired direction, the transmission path has attenuation, any taps may or may not add attenuation, and finally, there is loss in the coupling network connecting the power-line carrier receiver to the transmission line. By simple calculations, the net loss of the path between the transmitter and receiver therefore can be calculated. This article is intended to point out conditions that have been ignored in the past and means of measuring the characteristics of the coupling networks, associated traps, and the adjacent power equipment of the proposed channel before the channel is installed on the power system. This is accomplished by setting up a miniature of the section of the power system being studied on the analogue computer.

OPERATION OF ANALOGUE COMPUTER

THE OPERATION of an analogue computer has been explained previously in detail;[1–3] a brief résumé may be helpful. The power system to be studied is represented by a scale model using the same basic components as the actual system appears to have at the frequency or frequencies to be studied. The voltage used is of a convenient value to keep the current in the computer elements within their ratings. The impedance values of the system at carrier frequencies are generally scaled up to come within the range of the computer elements and the frequency base is scaled down to come within the frequency range of the computer. As an example of impedance and frequency base transformations, suppose it were desired to increase the original impedances by 2.5. All resistance values of the original system would be multiplied by 2.5, all inductance values by 2.5, and all capacitance values divided by 2.5. If, instead of changing the impedance base, it were desired to decrease the frequency base of the original system by a factor of 0.005, then all inductances and all capacitances would be multiplied by 200 and all resistances would remain the same. In carrier problems it is always necessary to change the frequency base and generally necessary to change the impedance base. Table I shows the conversion factors for making these changes.

Table I

Original System Constants	Computer Constants (R′, L′, and C′): Original Impedance Base Multiplied by "a" Only	Original Frequency Base Modified by Factor "n"	Impedance×"a" and Frequency×"n" Simultaneously
Resistance R	$R'=aR$	$R'=R$	$R'=aR$
Inductance L	$L'=aL$	$L'=L/n$	$L'=aL/n$
Capacitance C	$C'=C/a$	$C'=C/n$	$C'=C/an$
Frequency f	$f'=f$	$f'=nf$	$f'=nf$

In practice it has been found that the impedance multipliers usually come within the range of 10^0 to 10^2. The frequency base multiplier is generally fixed at 0.005, such that the frequency range of 40 to 200 kc will appear on the computer as the range from 200 to 1,000 cycles per second. To obtain the impedance multiplier, it is first necessary to calculate or obtain the actual values of impedances for the complete system as it is to be set up on the analogue computer. Knowing the maximum and minimum impedances on the system, and knowing the range of values available on the computer, the necessary multiplier *a* can be determined.

EQUIVALENT NETWORKS

THE COUPLING NETWORK can take several forms depending on the type of installation that is to be made. Figure 1 shows the actual network and the network used on the computer for single and double frequency coupling. Figure 1*A* is the schematic for a coupling capacitor and a

Full text of paper 52-219, "Application of Power-Line Carrier by Analogue Computer Studies," recommended by the AIEE Committee on Carrier Current and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Not scheduled for publication in AIEE *Transactions*.

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single-frequency line tuner and Figure 1*B* is for a coupling capacitor and a conventional 2-frequency line tuner. Other types of coupling networks can be set up similarly. The proper conversion multipliers are used to obtain all capacitance values and inductance values to be used on the analogue computer. Since the equivalent frequency is known on the computer, the individual resonant circuits can be isolated on the patchboard and the circuit checked for resonance. It should be noted that the equivalent circuit is identical to the original circuit and the only calculations necessary to obtain the values needed on the computer is the operation on the manufacturer's component values by the two factors a and n.

Single-frequency line traps are quite easy to simulate on the computer. There are two schemes commonly used for tuning. Figure 2 shows the schematics for these. Figure 2*A* uses a fixed main coil inductance, an adjustable capacitor, and a variable inductance. To make an equivalent circuit of this method of tuning, the main inductance and adjustable capacitor are set up and the variable inductance varied for resonance at the desired frequency. For setting up an equivalent of Figure 2*B*, the full value of inductance is used and the capacitance in parallel is varied for resonance. This method approximates closely the actual circuit, and if the point on the inductance to which the capacitor is tapped is relatively close to the end of the inductance, as the manufacturer generally recommends, this method is exact.

The 2-frequency trap is more difficult to duplicate in that mutual inductance must be incorporated in the equivalent circuit. This is accomplished by means of transformers on the analogue computer. Figure 3 gives the circuits commonly used for double-frequency traps. It is necessary to compute the values of inductance, both self and mutual, of each section of winding of the tapped inductances. However, if a double-frequency trap of the type desired is available, it is usually easier to set up the available trap for the two desired frequencies and actually measure the self- and mutual-inductance. There is one point that must be remembered when using this type of circuit: the effective Q of the equivalent trap is usually lower than the actual trap Q. However, if this point is remembered, the results can be properly interpreted and used.

Transformers, in general, are represented on the analogue computer as a shunt capacitance. Prior to studies made on power transformers at carrier frequencies,[4] it was generally assumed that a transformer presented a high impedance shunted across the line and a high attenuation through the transformer throughout the power-line carrier spectrum. The studies referred to have shown these assumptions may be false. Actually, for other than an autotransformer, the transformer appears as a shunt capacitance of essentially constant capacitance throughout the carrier spectrum. The approximate capacitance can be calculated by the methods commonly used in calculating surge voltage distribution of transformers or can be obtained by measurements and calculation.[5] Autotransformers are not quite as simple a configuration. Autotransformers can present either inductive or capacitive

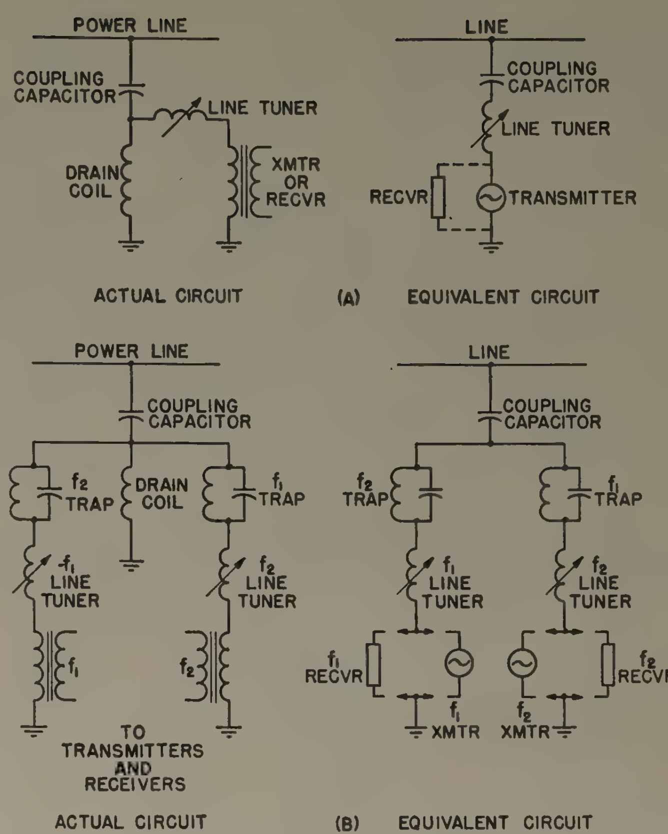

Figure 1. Actual and equivalent circuits for single- and double-frequency coupling networks

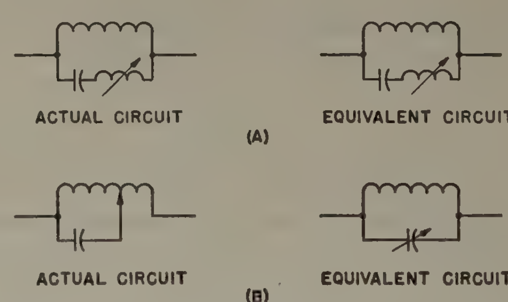

Figure 2. Actual and equivalent circuits for single-frequency line traps

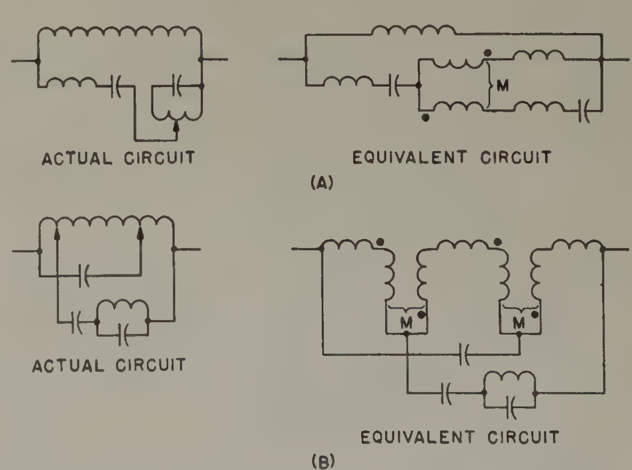

Figure 3. Actual and equivalent circuits for double-frequency line traps

Figure 4. Pi section equivalent of a transmission line

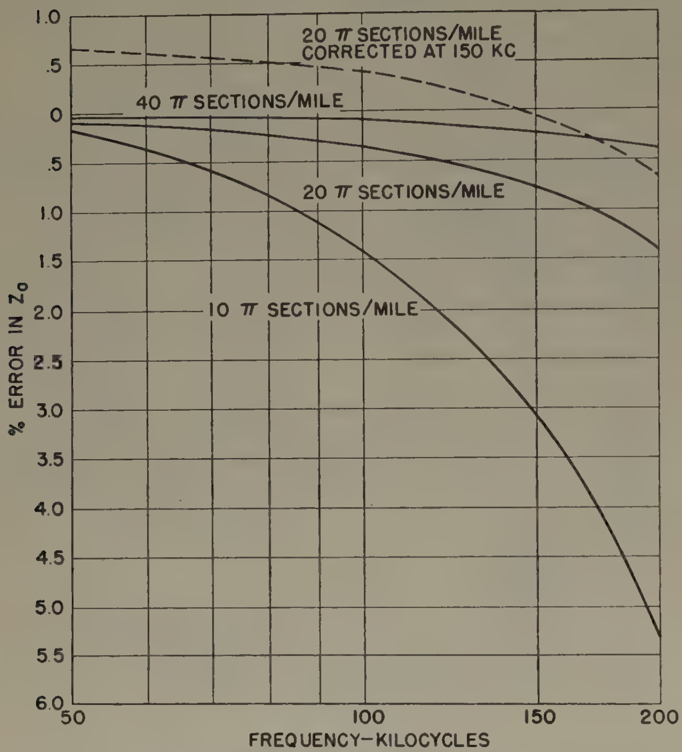

Figure 5. Error in characteristic impedance of an equivalent pi section for several equivalent lengths of line

reactance depending on the frequency and, therefore, must be represented by resonant circuits. Also, autotransformers are the least reliable in their through-attenuation characteristics and at some frequencies present a comparatively low through-attenuation. Other types of transformers generally present a comparatively high through-attenuation.

In setting up the equivalent of a transformer, it is, therefore, necessary to know the basic information about the transformer so that an equivalent network can be derived to represent the transformer on the analogue computer. After the characteristics of the transformer windings have been computed, it is then necessary to add a shunt capacitance to represent the transformer bushings which have varying values of capacitance, depending upon the manufacturer and rating.

Circuit breakers will appear on the analogue computer only as capacitance to ground. This is primarily due to the capacitance of the bushings. As could be expected, the capacitor-type bushing will have a higher capacitance to ground than the other commonly used types. Again, the capacitance-to-ground varies with the manufacturer and voltage rating of the bushing.

Transmission lines and cables are represented on the analogue computer by a series of pi-configuration networks as shown in Figure 4. This representation may be exact at a single frequency, but is only approximate when a band of frequencies is being considered. The basic equations for the equivalence of a transmission line and pi section have been well covered.[6,7] Due to the error in the equivalent representation of a transmission line by a pi network when a band of frequencies is being considered, a certain degree of error must be tolerated. As the degree of accuracy required increases, the number of elements required to represent a unit length of transmission line increases toward the limit of an infinite number of pi sections being exact over the entire band. Therefore, a compromise must be made between accuracy and the number of pi sections used to represent a given transmission line.

To represent a transmission line at power-line carrier frequencies, 40 to 200 kc, calculations have shown that it is necessary to use 20 pi sections for each mile of transmission line for a maximum surge impedance error of one per cent. Figure 5 shows the error with respect to frequency for three different equivalent lengths of pi sections. The required correction multipliers for modifying the value of inductance and capacitance for a given length of pi section is shown in Figure 6. The correction factor corrects the characteristic impedance of the pi section to that of the transmission line at the frequency at which the correction factor was calculated. The dotted line of Figure 5 shows the error if the pi section is corrected to be exact at a frequency of 150 kc. In this case, the maximum error has been cut in half by allowing either a positive or negative error to exist, depending on the frequency.

The representation of power cables is similar to that for transmission lines. It is necessary to use a single pi section to represent a shorter length of cable than of transmission

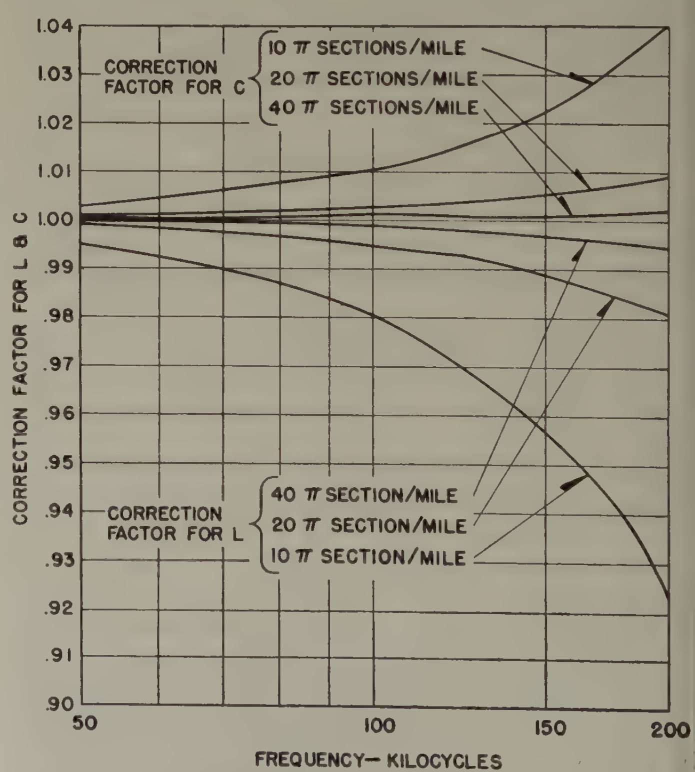

Figure 6. Correction factors for L and C of equivalent pi section for exact characteristic impedance at any frequency

line, if the same degree of accuracy is desired, because of the lower velocity of propagation through the power cable. In general, the same design of pi section can be used for most transmission lines. The design of pi sections for power cables is not as general, and it is necessary to use several designs to cover the same percentage of cable installations as the single design covers in transmission lines.

TYPICAL APPLICATION

THE BASIC TERMINAL NETWORK using a minimum number of reactive components is complex. Figure 7*A* shows one of the basic terminals commonly used with power-line carrier equipment. Figure 7*B* is the schematic of the terminal at carrier frequencies, the power transformer appearing as a capacitance. The reactance of the components is plotted against frequency in Figure 8 for an illustrative example of an application with nominal values assumed as follows: the coupling capacitor has a value of 0.004 microfarad; the line tuner is of the proper value to series resonate the coupling capacitor at 75 kc; the line trap has an impedance of 10,000 ohms and a Q of 75 at 75 kc, the resonant frequency; and the transformer has a capacitance of 1,000 micromicrofarads. The actual computed values of reactance with frequency are tabulated in Table II. If the capacitative reactance of the transformer is combined with the inductive reactance of the line trap, it is shown in Figure 8 that series resonance will occur at approximately 73 kc, which is a little below the frequency to which the line trap is tuned, but still within the nominal 3-kc side band. Table II indicates that the line trap has a resistive as well as reactive component. In this particular example, the resistive component of the line trap at the frequency of series resonance is approximately 400

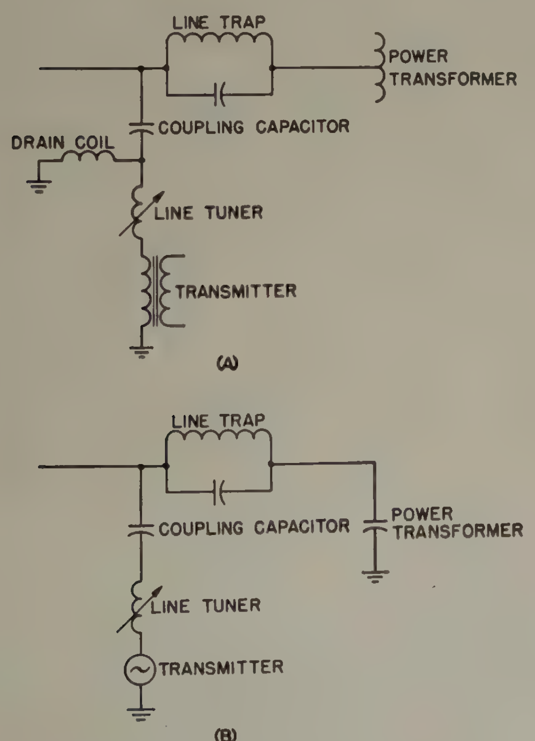

Figure 7. Equivalent representation of a basic terminal network

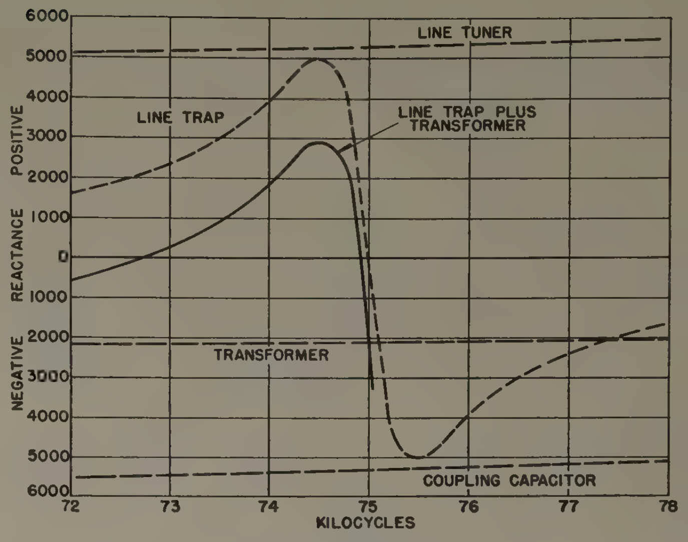

Figure 8. Reactance versus frequency for reactive components of basic terminal network

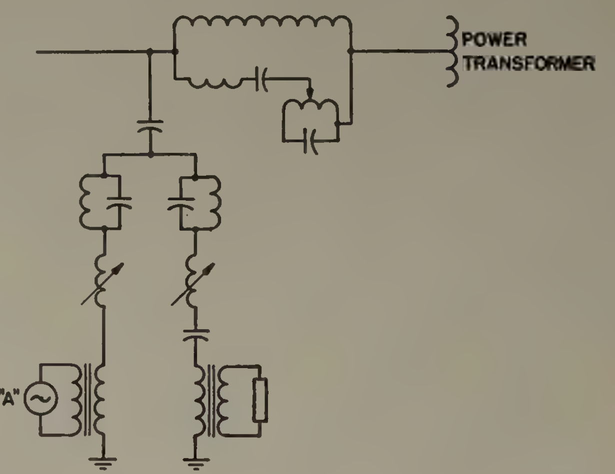

Figure 9. Schematic of 2-frequency terminal equipment

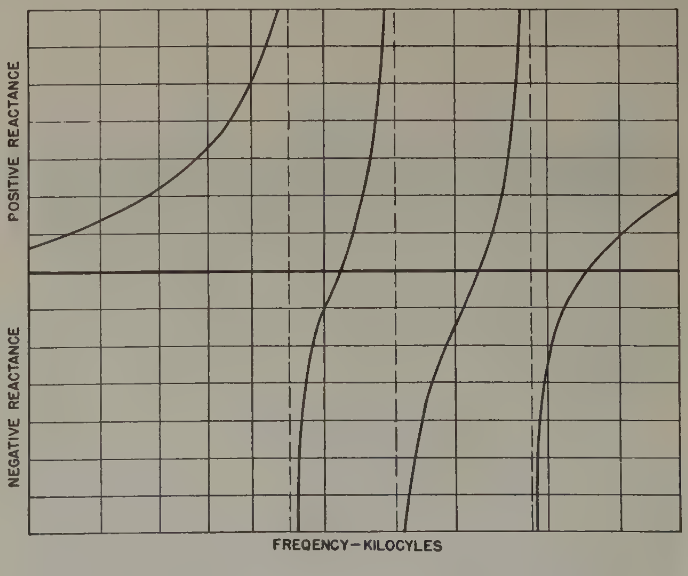

Figure 10. Typical reactance curve of 2-frequency terminal network

Table II

Frequency, Kc	Coupling Capacitor, Ohms	Line Tuner, Ohms	Line Trap, Ohms	Transformer, Ohms
72.0	−j5526	+j5093	278+j1574	−j2210
72.75	−j5469	+j5146	400+j2060	−j2188
73.50	−j5413	+j5199	974+j2995	−j2165
74.25	−j5359	+j5252	3000+j4615	−j2143
74.50	−j5341	+j5270	5000+j5000	−j2136
75.0	−j5305	+j5305	10,000+j0	−j2122
75.50	−j5270	+j5340	5000−j5000	−j2108
75.75	−j5252	+j5358	3000−j4615	−j2101
76.50	−j5201	+j5411	1042−j3025	−j2080
77.25	−j5150	+j5464	495−j2140	−j2060
78.0	−j5101	+j5517	286−j1623	−j2040

ohms. However, this is not always the case. As more complex power-line carrier terminals utilizing 2-frequency traps are substituted for this simple case, the resistive component of impedance of the line traps decreases to about one-half value. Thus, in the more complex terminals, the resistance component is an insufficient impedance to prevent a major loss of signal due to series resonance. Figure 9 is the schematic of a 2-frequency installation using a 2-frequency trap and a 2-frequency tuner. Figure 10 illustrates the complexity of the reactive component as seen by a transmitter at point *A* of Figure 9. It is apparent from this, that the use of the analogue computer in the solution of networks of this type permits not only the obtaining of the reactance characteristics much more quickly, but also permits finding new reactive component configurations for networks that indicate undesirable characteristics.

CONCLUSIONS

Series resonance of the line trap and transformer or other termination is a serious condition that has not generally been considered as existing at carrier terminals.

The analogue computer can be used to obtain complete reactive characteristics existing at power-line carrier equipment terminals.

Countermeasures can be checked rapidly on the analogue computer to obtain suitable solutions for eliminating series-resonant conditions.

The time required to make an analogue computer study is quite small compared to the time required for an analytical study, especially in the more complex terminals.

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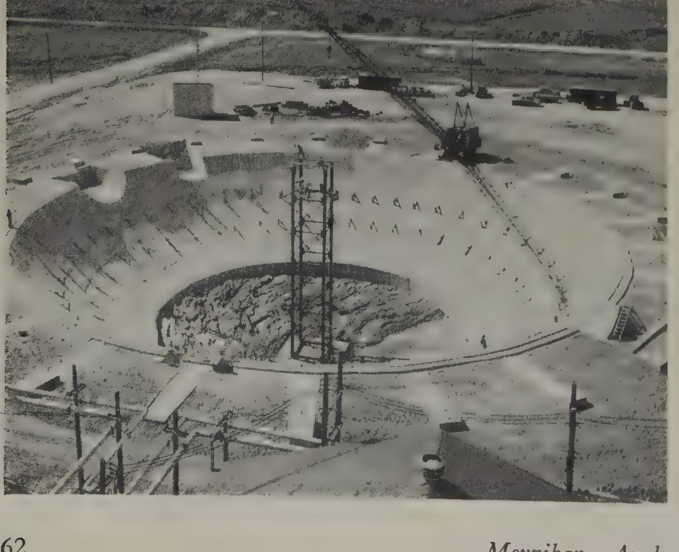
Saucer Foundation Completed on Building for Submarine Reactor

The saucer-shape foundation for the 225-foot steel sphere that is to house a nuclear submarine power plant being built by the Atomic Energy Commission for the United States Navy has been completed and work on assembling the hull of the land-based prototype submarine is underway.

The spherical design of the reactor building was adopted to give additional protection to operating personnel and to off-site areas during test operations beyond the many safety controls of the reactor itself. In the remote event that simultaneously all other controls failed, the resulting release of radioactive material would be contained in the sphere which will have a net free space of more than 5,400,000 cubic feet.



The outer periphery of the building will be 706 feet. The sphere will rest on the concrete saucer just completed which is 179 feet in diameter and 42 feet deep. A ring of steel columns set on concrete outside the structure and reaching to the middle of the sphere will give further support to the building. Welded steel plates will make up the skin of the ball. The plates will be hoisted into position by a derrick mounted on top of a temporary central steel tower. The derrick, now in place, reaches up 424 feet above ground level.

Every weld in the structure must be X-rayed to assure that there are no leaks. To do this on the bottom, a 4-foot space is provided temporarily between the base of the sphere and the concrete saucer. After testing is completed, this sphere will be filled with concrete and aggregate. Inside, the concrete floor on which the reactor will rest will be slightly above ground level and the well of the saucer beneath the floor will be filled.

Tensorial Analysis of Transmission Systems—III

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FELLOW AIEE

WITH THIS PART the study of several interconnected transmission networks begins. Numerical calculations of I^2R losses in the component divisions of a typical, radially connected system are given in a companion paper[1] for various power-interchange conditions.

A transmission network, even in its steady state, is far more than a stationary network. First of all it is a dynamical system, since its terminal voltages swing in angular displacement and magnitude as the loads vary. Moreover, a transmission system is in many respects like a living organism. It actually grows in size and in the type of organs it possesses. It is needless to point out that all over the United States most electric power systems double in physical size about every 10 years. It seems reasonable to demand that as new transmission lines are added to the system, or new power plants are built, there should be no need to start the numerical and analytical study of the augmented system all over again from the beginning.

Attempts will be made to organize all concepts and tensors in such a manner that they should grow with the system they represent. Attempts will be made to systematize the analysis so as to be able to foretell and supervise the direction in which the organism should grow, in order to stay healthy in both technical and economic sense.

Already the first step in interconnecting transmission systems of several companies is spearheaded by two important considerations. Assuming that the constants of each individual division already have been measured, calculated, and used in individual system studies on previous occasions, the effect of interconnections should not require any additional a-c board measurements and should not require the recalculation of the system constants. Assuming that the combined performance of the interconnected system has been calculated, it should be possible to pass back to each individual division and determine its performance also from the already available data for the interconnected system.

If each company has available the needed constants of its own transmission system as required for its own needs, the same constants should be and will be used as starting points to study the performance of any desired combination of divisions, without the necessity of starting from the beginning for each combination. Also, it will be possible to translate the performance of the combined system into the language of each operating division.

As long as it is assumed that the powers flowing through all individual tie-lines are known, the previous studies are sufficient for all purposes.[2] However, when the assumption is made that only the resultant power passing through each set of tie-lines connecting two divisions are known, then the present study must be undertaken.

As less information becomes available even about the resultant interchange powers passing across the various sets of tie-lines, the analytical study of losses, economic loadings, and other problems become increasingly more involved. Hence, even the present study will have to be extended for cases, where only the amount of power bought or sold at particular tie-lines are known, but their path of flow through the combined system is unspecified.

When an interconnected transmission system is subdivided into its component divisions, these units differ from each other in the manner in which the interchange powers cross their territories. Some divisions only sell power to several others, some merely buy power, some only act as transfer channels, and some divisions perform two or more of these transactions simultaneously.

Hence, in the subdivided units still further steps have to be made before the analysis may start. The power flow in each division must be adjusted to have identical pattern. In particular, the several tie-lines leading to one neighboring division will be replaced by one "hypothetical" tie-line that carries the total interchange or sum power. Each division has as many hypothetical tie-lines as it has neighboring divisions. The power in each division will be assumed to flow from each generator and from each hypothetical tie-line straight to the hypothetical load of that division.

A division having such a simplified radial power flow will be called a primitive division. Hence, the analysis of interconnected transmission systems will consist of three main series of steps: 1. The equations of the primitive division are established. All currents flow radially. 2. The radial power flow in each division is replaced by a general crisscross flow of power. (This step is analogous to the rotation and interconnection of windings and brushes in each rotating machine.) 3. The divisions are interconnected into one system and the performance of the resultant system and of the individual divisions is determined.

In a general power pool the member companies usually form several closed loops, in which "sneak" powers circulate. Also external companies adjoin the pool through another series of ties, whose effects upon the losses of the pool members also must be considered.

Digest of paper 52-192, "Tensorial Analysis of Integrated Transmission Systems—Part III," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Electronic Equipment in Fighter Aircraft

A. R. ANDERSEN

The necessity of electronic equipment in fighter aircraft is acknowledged, but the need for co-ordination of the various equipments to produce a completely integrated weapon is emphasized. Examples of the difficulties inherent in the present approach graphically dramatize the gravity of the situation.

PRIOR TO THE latter part of World War II, a relatively small amount of electronic equipment was required in fighter aircraft designed and built under military contracts. However, it became clear during World War II that fighter air power could not be restricted to fair-weather daylight activity. Therefore, the Armed Forces strongly encouraged the development and manufacture of electronic equipment to remove this restriction. After World War II there was a comparatively quiescent period which lasted almost until the fighting began in Korea. Now the situation is similar to that during World War II. Unfortunately, various military agencies have had different ideas about what particular equipment should be developed, how it should be packaged, what type of power it should operate from, and just exactly what the equipment should do. Under these conditions it apparently was not realized that someday a large number of these equipments would be installed in the same aircraft.

The story of the man who telephoned the Harvard Electronic Computer Laboratory is pertinent. The telephone rang a number of times and was finally answered by a hollow monotonic voice which said "There's nobody here but us complicated electronic gadgets." This situation is being approached in fighter aircraft. The dollar value of the electronic equipment in many modern fighter aircraft equals or exceeds that of the airframe.

The aircraft manufacturer is confronted with a host of strange electronic devices which he is told must be put into his newest airplanes. However, the equipments do not appear to the aircraft manufacturer as though they were built by people who had any conception whatsoever of the space, weight, and drag limitations of fighter aircraft.

Each of these equipments is an entity unto itself. When they are assembled in the same aircraft, the resulting electronic system resembles Hydra with a myriad of uncoordinated ears, noses, eyes, brains, and hearts together with many miles of interconnecting veins, arteries, and nerve fibers. One brain, one heart, and several eyes would have been at least equally as effective.

A survey of one manufacturer's fighter aircraft revealed that after all the separate electronic equipments were installed there was a total of eight gyroscopes in the airplane. Closer investigation revealed that only two were really needed as all equipments requiring gyroscopes could have utilized signals from these two. It may seem, at this point, that the solution of this particular problem is obvious: merely eliminate six gyroscopes and connect the other two into all equipments requiring gyroscopic signals. Unfortunately, it is not as simple as that. Some gyroscopes have microsyn pickoffs; some have autosyn pickoffs; some have potentiometer pickoffs supplying d-c output signals; some have potentiometer pickoffs supplying a-c output signals; in addition the potentiometer resistances range from low to high, and the output impedances range accordingly. Some gyroscopes have 3-phase motors requiring a-c excitation of closely controlled frequency, and this voltage is usually supplied from the particular equipment using this type of gyroscope. Others operate from the aircraft a-c supply and have their speed controlled by special devices inside the particular equipment with which they were originally designed to work. From this by no means complete discussion it should be clear that it is not a simple matter of eliminating six gyroscopes from the equipment even though functionally two gyroscopes could well serve the purpose. If, in the initial design of each separate equipment, the gyroscopic requirements had been co-ordinated, six very costly units could have been kept out of the fighter, and the cost, weight, and complexity of the fighter would have been reduced appreciably. Hindsight, however, comes much more easily than foresight, but this is only one of many such incidents. It has been found that in one fighter 160 pounds of equipment were devoted to computation of a certain quantity due to a duplication of this particular computation between the optical and radar fire-control systems.

Another difficulty brought on by the present modus operandi is that of interference between equipments installed in the same airplane. As one example of this, a jet fighter pilot calling into the tower for landing instructions might say "Pilot to control tower, my altitude is 10,000, no, 5,000 feet. Are there any mountains around here?" Investigation would reveal no doubt that talking into the radio transmitter caused the radio altimeter reading to fluctuate. Another example would be a jet fighter "galloping through the sky like a ghost rider." Probably it is caused by the radar antenna scanning back and forth. Each time the direction of scan reverses, a large amount of current is drawn from the airplane power source. As the same power source also supplies the auto-

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pilot, which is somewhat supply-voltage-sensitive, it results in periodic aileron and elevator deflections affecting the flight course markedly.

Some of the government-furnished equipment supplied to the aircraft manufacturers requires 3-phase delta-connected power. Others require 3-phase Y-connected power. Some require single-phase power. Still others require power that is not available in any airplane, such as 400-cycle power, frequency regulated to within ± 1 cycle.

It is necessary to interconnect the audio outputs of a number of pieces of equipment, such as the radio communication receivers, the radio compass, and certain navigational equipment, and feed the combined output into the pilot's earphones. This would be a simple matter if the output stages of equipments with audio outputs had been designed with this thought in mind. Unfortunately they were not so designed. Practically no two of these devices have audio output provisions which are compatible. Simple as this problem seems, a completely satisfactory solution has not yet been found.

Observation of the end result of the present modus operandi clearly reveals the need for a master plan which requires close co-ordination among those who determine what goes into the detailed specifications for government-purchased air-borne electronic equipment. A fighter airplane, its electronic equipment, and its armament must be efficiently integrated if a truly powerful weapon is to result.

It is necessary for the aircraft manufacturer to take a large share of the responsibility for the proper operation of electronic equipment installed in aircraft. As the number of equipments has increased, there have been corresponding increases in the amount of space required for the equipment, the amount of electric power required, the number of antennas, the number of special provisions for gaining quick access to the equipment, and the amount of heat which must be dissipated. It is no longer possible to design a fighter airplane first and install all the electronic equipment in it afterwards. The design of the airplane is now acutely dependent upon the electronic equipment which will be installed. At the outset of the design of a new airplane, the aircraft manufacturer must obtain all details on electronic equipment to be installed, keeping the following considerations in mind: Each component must be located to best advantage from the standpoint of cable lengths, interference pickup, interference radiation, accessibility, maintenance and preflight adjustment, airplane balance, freedom from vibration, gun shock, exhaust gases, corrosive fumes, hydraulic fluid, rain water, salt spray, and fuel. Antennas must be located so that proper operation can be obtained under all configurations of the aircraft, that is, in the landing configuration with the wheels down and the external stores configurations when bombs or extra fuel is being carried. Antennas and transducers must be located in positions where they are not vulnerable to damage in normal usage and during servicing of other parts of the airplane. The antennas must be housed in streamlined enclosures of proper design, both structurally and electrically. The equipment must be properly ventilated and cooled since most pieces of electronic equipment installed in an airplane are approximately 98 per cent inefficient and most of the power supplied to them is turned into heat.

One of the newest and most difficult problems with which the aircraft manufacturer is faced is the design of a satisfactory enclosure for the antenna of the radar fire-control system. This enclosure, as most of you know, is called a radome. The fire-control radome is usually in the forward part of fighter aircraft and its structural design must be such as to stand up under all bending, twisting, and ram pressure conditions encountered in flight. It must also have a high degree of transparency for radar waves of a given frequency. To be suitable aerodynamically, the radome must be of a streamlined shape such as a parabola, cone, or ogive. The optimum configuration from an electrical standpoint would be a hemispherical radome, but this is not permitted because of the aerodynamic consideration. The radome must also be constructed in such a manner that it does not bend the radar waves passing through it. A radome which bends the radar signals from a fire-control radar would be comparable to an optical gun sight which has a poor lens and bends the light rays coming through it. Radomes must withstand the high temperatures encountered in high-speed flight. For example, at 650 miles per hour the temperature rise of the ram air impinging against the tip of the radome is approximately 75 degrees Fahrenheit above the ambient. At sea level, this could result in temperatures of 175 degrees Fahrenheit. The radome must withstand the effects of flight through heavy rainfall. Radomes for precision applications should be of circular cross section to permit close thickness and contour tolerances to be held in manufacture.

Another problem which faces the aircraft manufacturer is that of properly cooling the electronic equipment. As mentioned earlier, electronic equipment is, in general, approximately 98 per cent inefficient and hence large amounts of heat must be disposed of to prevent the temperature of the components from exceeding the value for which they were designed. It would seem at first hand that the ideal solution to such a problem would be to supply cooling air from the refrigeration system which must be installed in the airplane to cool the pilot when flying at low altitudes and high air speeds. This type of cooling always requires a large increase in the size and weight of the refrigeration equipment, and, in general, is not feasible. The two methods most commonly employed at present make use of either ram air (obtained by flush ducts in the fuselage), or cabin exhaust air, which is quite useful for cooling the radar system since what is warm for the pilot is cool for the radar. Ram air is very effective above about 15,000 feet but at high speeds near sea level the temperature of the ram air may be too high to use for cooling purposes. Most of the electronic equipment used in aircraft is built to Army and Navy Specification *AN-E-19* which requires that the equipment operate satisfactorily in ambient temperatures from -67 to $+131$ degrees Fahrenheit at altitudes from 0 to 15,000 feet and from -67 to 86 degrees Fahrenheit at altitudes above 15,000 feet. It is up to the aircraft manufacturer to maintain the electronic equip-

ment compartment within this temperature range. It is the responsibility of the equipment manufacturer to distribute the heat homogeneously inside the electronic units to avoid hot spots when the equipment is operating at the maximum ambient temperatures specified.

The requirement that the aircraft manufacturer make all the foregoing provisions in the airplane during the initial design period of the airplane presents a serious problem in keeping aircraft up-to-date as fighting weapons. Several years are usually required between the time that the design of a new airplane starts and the time that the first production model is delivered. During that 2-year period new electronic equipment will be developed. The airplane which is designed around existing electronic equipment will then have to be delivered with obsolescent equipment. This problem is recognized by the Armed Services. The present approach to the problem is to have the agency which is developing the electronic equipment work closely with the aircraft manufacturer in order that changes required in the equipment or the airplane can be closely co-ordinated. Of course, a good initial estimate must be made of space and power which the new equipment will require. After more experience is gained with this approach, it may be found that only tried and proved electronic equipment is feasible for fighter application, and that the price of slight obsolescence is less than the price of installation of unproved equipment.

The tremendous increase in the amount of electronic equipment used in fighter aircraft has been and still is a controversial subject. The typical fighter aircraft manufacturer is a very conscientious man with great prides and great prejudices. He takes great pride in the performance of his aircraft and accordingly views suspiciously the addition to the airplane of anything which occupies space and is susceptible to gravity. The performance of any fighter can be ruined by the addition of enough weight. The motto of the aircraft manufacturer is "every ounce counts." He fights a never-ending battle within his own walls to keep the weight of his aircraft at an absolute minimum. A glance at some of our so-called "air-borne" electronic equipment reveals that the frontiers of this struggle must be advanced deep into the territory of the electronic equipment manufacturers. The aircraft manufacturer is concerned with such seemingly minute weights as the excess material in a screw head, the weight of insulation on a wire, the weight of a small bracket, and the weight of any bracket or structural member however small that is not absolutely essential. The maxim, "When in doubt, leave it out," epitomizes the aircraft manufacturer's attitude. Stress analysis and static test are combined to insure that there is no excess weight in that part of a fighter airplane built by the aircraft manufacturer. Equipment manufacturers would do well to follow this example.

There is much in the literature about the progress that has been achieved in the subminiaturization of electronic equipment. An amplifier for hearing-aid use can be completely contained, including batteries, in a package small enough to fit in the vest pocket of the wearer. The walkie-talkie equipment used by the Army has had the subminiaturization technique applied to it with an appreciable reduction in size and weight. The electronic system for the proximity fuse has been completely packaged inside a projectile and yet is able to withstand the heat and shock encountered in the firing of the projectile. Now, over 7 years since the proximity fuse was developed, there is not a single subminiaturized piece of electronic equipment in the most modern fighter airplanes where space is almost as much at a premium as in the proximity fuse. The electronics industry has here taken the path of least resistance and has adhered to the use of packaging techniques which are outmoded for fighter applications.

For the benefit of electronic manufacturers interested in supplying aircraft, it can be said the surest way to an aircraft manufacturer's heart (and his pocketbook) is through his stress on weight, size, and reliability. Offer equipments and components of out-of-the-ordinary reliability exhibiting a visible effort to keep weight and size to a minimum and the response will be favorable. The lowest bidder does not always get the contract. Although most people like to get the most for their money, the aircraft manufacturer, in a sense, likes to get the least for his money.

Electronic equipment is noted for its unreliability. The use of redundant systems to achieve reliability is not permissible in fighter aircraft. The vacuum tube is by far the worst offender. Statistics show that vacuum tubes alone account for approximately 65 per cent of equipment failures. The next nearest contenders are resistors and capacitors at about 8 per cent each. It is not surprising that vacuum tubes designed for use in home radios fail to give reliable service in aircraft. However, it is surprising that home radio tubes are still used in fighter aircraft electronic equipment. Some fighters contain over 500 vacuum tubes. The unreliability of the vacuum tube was finally considered of sufficient importance to merit attention by the commercial air lines. As a result, a series of tubes known as *ARINC* tubes were developed by Aircraft Radio Incorporated under the sponsorship of the commercial air lines. The air lines wisely chose ten tube types upon which to concentrate. These ten tube types were chosen to fill the majority of the air-line needs. The goal of the air lines was to reduce the number of failures in the first 1,000 hours of operation to 2.5 per cent. The major characteristic desired is not necessarily long life but satisfactory performance between predetermined replacement periods. These tubes have now been in use by the air lines for a number of years. Some of these tube types have a reliability of 99 per cent in the first 1,000 hours of operation, and this dependability is being maintained through several additional thousand hours.

In the design of equipment for aircraft use, the equipment manufacturer must take great care to assure that all tubes and all components are worked well within their ratings. Frequently, components must be derated when used at high altitudes and high temperatures. An example of this which has been overlooked in the design of electronic equipment being used in fighter aircraft is that vacuum tubes must be derated sometimes as much as 30 per cent when operated at high altitudes. Usually in the development of a new piece of equipment, the electronic engineers

work with only one or two models of the equipment, and this work is usually done under laboratory conditions which are by no means representative of the conditions under which the equipment actually operates in service. It is true that specifications spell out the conditions under which the equipment must operate in service, but the electronic designer is usually so intensively concerned with achieving the particular function of the equipment that he concentrates only on this problem and frequently consoles himself with the thought that reliability can be designed into the equipment later. Usually the redesign does not take place. Frequently, the prototype design may be put directly into production. The equipment manufacturer must avoid becoming so involved in the problem immediately at hand that the ultimate goal is lost sight of. In order to appreciate fully his responsibilities, the equipment manufacturer must occasionally imagine himself in the role of the individual who ultimately will use his equipment. The man who uses an unreliable revolver in a duel will be much more concerned about it than the engineers who designed the revolver in a distant laboratory.

Fighter aircraft must be capable of the functions which the electronics industry can give them, but the equipment must be light, efficient, and reliable. The military agencies realize the need for efficiently integrated fighting weapons rather than unco-ordinated separate entities. United States air superiority depends upon having fighter aircraft with efficiently integrated electronic systems of minimum size, minimum weight, and maximum reliability. A new era in fighter air power will be ushered in by the integrated weapon concept. Future progress depends upon how fast it can be attained.

Applicability of Isotopes for Specific Uses

Isotopes in common use in industry and research today and the applicability of each for specific uses are shown in the following table released by Isotope Products Limited.

How useful each of the isotopes shown in the table is for any given application depends on the type of rays emitted or radiation energy and how long they last or half-life.

Radiation energy is comparable to frequency and wavelength in measurement of light or radio waves and is an important factor in determining the penetration of radioactive rays. It is measured in mega-electron volts. Isotopes emit alpha, beta, and gamma rays and each of these can be graded by their mega-electron volts much the same way as radio waves are graded in megacycles.

Higher energy gamma rays require greater lead shielding; beta rays of higher mega-electron volts penetrate thicker sheet material. An isotope's radioactivity in mega-electron volts is like the voltage of an X-ray machine. The higher the mega-electron volts or voltage, the more energy of the X ray or isotope ray.

Half-life is the measure of an isotope's effective life. All radioactive materials decay, but each at its own fixed rate of deterioration. The amount of radioactivity, measured in curies, declines, though the type of rays, alpha, beta, or gamma, and the energy of those rays, in mega-electron volts, stays constant.

The half-life is the period of time till a radioactive source is emitting rays at only half its initial rate of emission. The rays have the same penetrating power, but as the material ages, its radioactivity slows down. The radioactive rays are kicked out of the atom less frequently, but with just as much power.

ISOTOPE	HALF-LIFE	USEFUL RADIATION	USES
Antimony 124	60 days	Gamma mixed energies	In tracing and process control in the oil industry.
Cerium 144 and Caesium 137	290 days 33 years	Gamma mixed energies	These are the main long-lived residue from atomic piles; use is being tested for food sterilization, and so forth.
Carbon 14	6,000 years	Low energy beta	Widely used research tool, particularly in biological studies and dating anthropological materials.
Cobalt 60	5.3 years	Penetrating gamma	Radiography of thick materials; the cobalt "bomb"; food sterilization; oil pipe-line tracing.
Iodine 131	8 days	Low energy gamma	The most widely used isotope in medical field; used for thyroid treatment.
Iridium 192	70 days	Low energy gamma	General-purpose industrial radiography; particularly for field work; used in corrosion gauge.
Phosphorus 32	14.3 days	Penetrating beta	In research on bone growth and fertilizer action.
Radium	1,660 years	Mixed energy gamma	Little used now for radiography; still used for luminous paint and static elimination.
Sodium 24	14.8 hours	Very penetrating gamma	Radiography of very thick materials, tracer work where rapid decay is essential.
Strontium 90	25 years	High energy beta	Heavy sheet thickness gauges; medical use involving external radiation.
Thallium 204	2.7 years	Medium energy beta	Thin sheet thickness gauges.

IN-420: A New Chlorinated Liquid Dielectric

A. J. WARNER
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THE PAST FEW years have witnessed a steady increase in the use of chlorinated hydrocarbons in electrical components. These high dielectric constant insulating materials have been found particularly suitable for applications such as capacitor impregnating liquids. The search has continued steadily for additional chlorinated materials possessing improved performance characteristics under prolonged electrical stress.

Related to this general interest, a family of new liquid dielectrics, the chlorinated phenylindans, has been developed. The structural formula of one member of this series, dichloro-1,3,3-trimethyl-1-phenylindan, to which the name IN-420 has been assigned, is shown in Figure 1. It is especially suitable as a capacitor impregnant.

Both the physical and electrical properties of this material have been extensively investigated. In appearance it is a clear, slightly yellow-colored substance having a bluish fluorescence. It is of medium viscosity. The refractive index, specific gravity, and boiling point are similar to those of the chlorinated biphenyls (Aroclors).

The electrical properties of IN-420 have been determined using a rhodium-plated, guarded test cell. The values of dissipation factor and d-c volume resistivity are comparable to or somewhat better than those obtained with existing commercial chlorinated biphenyls. Its dielectric constant and dielectric strength are markedly superior to those of the existing chlorinated biphenyls. Thus, measurements of the dielectric constant of IN-420 and Aroclor 1254 at 50 degrees centigrade gave averaged values of 5.31 and 4.80, respectively. For the dielectric strength properties, determined for an electrode spacing of 100 mils, comparative tests gave readings of greater than 45 and greater than 35 kv, respectively.

On the basis of the promising physical and electrical results obtained with this new material, it was considered desirable to obtain some specific performance data under conditions of actual use as a capacitor impregnant. Accordingly, capacitors were assembled comprising 0.005-inch-thick aluminum foil separated by two thicknesses of 0.0004-inch unbleached kraft capacitor tissue. These units had a capacitance of approximately 0.06 microfarad

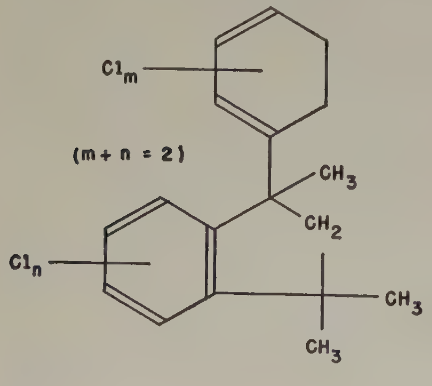

Figure 1. Structural formula of dichloro-1,3,3-trimethyl-1-phenylindan

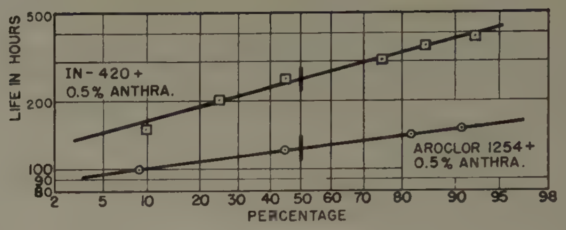

Figure 2. Continuous life-test data at 120 degrees centigrade and 600 volts direct current of capacitors impregnated with stabilized IN-420 and Aroclor 1254

when impregnated. For comparison purposes, Aroclor 1254 was used as the impregnant in half of the units assembled. In some of the experiments, known stabilizers were added to the chlorinated impregnants.

Several of the units were put on continuous life test at 450 and 600 volts direct current, and at temperatures of 120 and 125 degrees centigrade. The point at which 50 per cent of the capacitors failed, under comparative test conditions, was determined for purposes of evaluation.

It was found that under all test conditions of voltage and temperature used, capacitors impregnated with IN-420 showed a significant and, at times, marked superiority in life test characteristics when compared with Aroclor 1254 impregnated capacitors. This superiority applied, although not as markedly, even where the Aroclor contained 0.5 per cent anthraquinone as a stabilizer.

Thus, typical data obtained on a comparative basis at 120 degrees centigrade and 450 volts direct current showed a 50 per cent failure point for Aroclor 1254 of 85 hours. Stabilization of the Aroclor with 0.5 per cent anthraquinone raised this value to 300 hours. For IN-420, comparable values for the nonstabilized and stabilized compounds were 375 and in excess of 2,000 hours, respectively. At the higher temperature of 125 degrees centigrade, a corresponding superiority was again maintained, the 50 per cent failure points being 35 and 85 hours for the Aroclor 1254 and the IN-420, respectively. A comparison at 600 volts direct current, shown in Figure 2, revealed similar relative differences in life-test performance.

The foregoing data indicate, therefore, that this new chlorinated liquid dielectric, IN-420, possesses certain physical and electrical characteristics of value in capacitor applications. It appears particularly suitable for use at elevated temperatures where its remarkable stability under electrical stress can be exploited.

Digest of paper 52-227, "Electrical and Physical Properties of IN-420: A New Chlorinated Liquid Dielectric," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Trip-Free Reclosing Circuit-Breaker Mechanism

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THE DEMAND FOR ever higher interrupting capacities and ever shorter interrupting and reclosing times of power circuit breakers has presented a challenge to the designer of the circuit-breaker operating mechanism. The gauge of this challenge is the achievement of interrupting times as short as 3 cycles and successive reclosing times, without intentional time delay, as short as 15 cycles, all without sacrifice of simplicity and reliability.

The principle of mechanically trip-free operation can be accepted as a basis for design with the assurance that its proper embodiment will meet this challenge. In the development of such an embodiment there are two conditions which require due recognition.

The first, identified with 3-cycle interrupting time, is the permissible time of only $1^1/_4$ cycles from trip-coil energization to contact parting. This condition imposes no pneumatic problems whatever, but does present the problem of extraordinary initial acceleration of certain mechanical components.

The second, identified with successive 15-cycle reclosures, imposes the problem of accomplishing an exceptionally high rate of dumping of closing compressed air from behind the closing piston to assure positive and consistent recoupling of the trip-free mechanism.

Figure 1 illustrates how a 4-bar linkage has been arranged to provide a simple and reliable solution to the problem imposed by the first condition, giving: 1. mechanically trip-free operation through a simple latch and single trip coil; 2. reduced tripping force through a toggle reduction; 3. low mass inertia of moving parts through compression loading of linkages and latches; and 4. reduced friction through use of rolling rather than sliding surfaces.

A maximum of reliability is secured through: 1. use of shim instead of screw adjustment; 2. cushioning against harmful vibration at its source; 3. increased force near closed position through a closing toggle to overcome the extreme final closing loads which may be encountered; and 4. consideration to corrosion resistance.

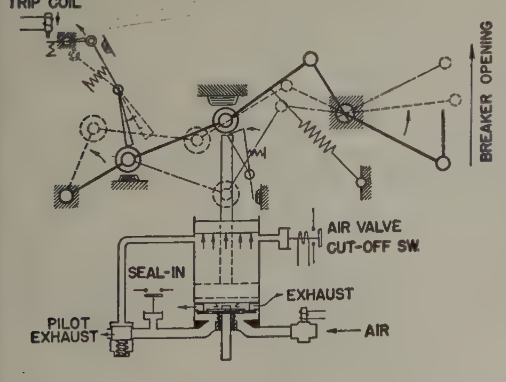

Figure 1. Diagram of PN-12 Operator. Solid lines indicate closed, dotted lines tripped-free, and dot and dashed lines open position of linkage

The cylinder arrangement illustrates a unique but equally simple and reliable solution to the problem imposed by the second condition. An intermediate casting between the cylinder and the lower cylinder head is arranged with an annular opening near its outer wall. A light exhaust valve disk closes this annular opening to prevent loss of air during a normal closing operation. Closing compressed air enters the lower casting, flows through a number of holes in the exhaust valve disk, and forces the piston upward. Near the end of the stroke, a blast of air admitted to the air valve cutoff switch interrupts the solenoid closing-valve current thus stopping the flow of air into the cylinder. Meanwhile a small pilot exhaust valve opens and the decay of air pressure in the lower head casting forces the exhaust valve disk downward. The air in the operating cylinder then exhausts through the 24-square-inch annular opening uncovered by the valve disk. The flapper valve prohibits a return flow of air through the holes in the exhaust valve disk.

Unique to this application are two special air-operated controls which eliminate the need for Y and X relays. The air valve cutoff switch functions as a small air-blast circuit breaker de-energizing the solenoid air valve in 0.2 cycle. Equipped with a holding coil, it also prevents pumping. The pneumatic seal-in switch seals in around the closing control contacts as soon as pressure enters the cylinder. This not only provides for completion of a closing operation, once started, but also prevents sealing-in the solenoid air valve when no pressure is available at the valve.

A maximum of engineering information was obtained while testing a prototype of the final mechanism under the most severe operating conditions, employing modern instrumentation including an oscillograph, superspeed motion picture camera, resistance-type strain gauges, pressure recorders, multichannel amplifiers, and other specially developed devices.

In addition to performance tests, life tests, maximum loading tests, trip-free operations, and so forth, engineering information included measurement of transient stresses, transient air pressures, accelerations and velocities of various moving parts, and a record of the true paths of motion of the 4-bar linkage during closing and tripping.

The performance of the operator throughout these tests has been gratifying. It has substantiated design calculations, and has demonstrated that mechanically trip-free operation, always highest in speed of tripping, is not incompatible with superhigh-speed repetitive reclosing.

Digest of paper 52-170, "Developing a Superspeed Trip-Free Reclosing Circuit-Breaker Mechanism," recommended by the AIEE Committee on Switchgear and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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ASA Transformer Standards C57.22

Temperature Rise Tests on Transformers

AIEE PROJECT GROUP

A SHORT TIME AGO a subcommittee of the AIEE Transformer Committee was appointed to study the proposal that the short-circuit method of making temperature rise tests on transformers be the preferred method. The subcommittee report recommending that the proposal be accepted was approved by the Transformer Committee. The subcommittee report was presented at the 1950 AIEE Winter General Meeting in New York, N. Y., as Miscellaneous Paper 50–99.

The subcommittee felt that the entire section on temperature rise tests in the Test Code should be reviewed, and revised where desirable, before the material on the short-circuit method of temperature rise testing was forwarded to the American Standards Association (ASA) Committee on Transformer Standards. Accordingly, the subcommittee carried on its work and a preliminary report was presented to the Institute at the 1951 Winter General Meeting as Miscellaneous Paper 51–134, in the hopes that constructive comments would be received.

The principal modifications of the test code are

1. Confirmation of the preference for the short-circuit method of making temperature rise tests.
2. Casting out of the zero-sequence method of temperature tests on these phase transformers, because of the inherent defects in the method.
3. Refinements in the testing procedure.
4. Improvement arrangement.

TEMPERATURE RISE TESTS

22.500. Methods of Loading for Temperature Rise Tests

(a) Transformers shall be tested under loading conditions that will give losses approximating, as nearly as possible, those obtained under the nameplate rating. See *12.042* for conditions under which temperature limits apply, and use the tap connection giving the highest losses.

Paragraph *12.042* requires that the temperature test be made under the condition of delivering rated kilovolt-ampere output at rated secondary voltage. This requires a slight overexcitation. In accordance with the footnote under Paragraph *11.016*, the resultant increase in total loss has a negligible effect on the kilovolt-ampere output. It is therefore not considered in the temperature rise test methods described herein.

(b) Various methods are available for this test. These are

(1) Actual Loading
(2) Simulated Loading
  (2a) Short-Circuit Method
  (2b) Loading-Back (Opposition) Method

22.505. Actual Loading

(a) The Actual Loading Method is the most accurate of all methods, but its energy requirements are excessive for large transformers.

(b) Transformers of small output may be tested under actual load conditions by loading them on a rheostat, bank of lamps, water box, and so forth.

22.510. Simulated Loading

(a) The Short-Circuit Method necessitates an accurate predetermination of excitation losses and copper losses, including stray losses, at operating temperature. It has the advantage of permitting a direct measurement of the watts and current being held during the temperature rise test. This method requires a smaller amount of testing facilities and energy consumption. It is particularly suitable for the larger size transformers, and is equally satisfactory for small transformers.

(b) The Loading-Back (Opposition) Method requires a greater amount of testing facilities and auxiliary equipment, and also energy consumption. Because of these requirements, the Loading-Back Method becomes increasingly difficult to perform as the size of the transformers increases.

22.515. Temperature Rise Tests—All Transformers

All temperature rise tests shall be made under normal conditions of the means, or method, of cooling.

(a) Transformers shall be completely assembled and if oil-immersed they shall be filled to the proper level.

(b) If the transformers are equipped with thermal indicators, bushing-type current transformers, and so forth, such devices shall be assembled with the transformer.

(c) The temperature rise test shall be made in a room which is essentially free from drafts.

(d) The temperature of the surrounding air, ambient temperature, shall be determined by at least three thermocouples, or thermometers, spaced uniformly around the transformers under test. They should be located at about one-half the height of the transformer, and at a distance of 3 to 6 feet from the transformer. They should be protected from drafts and abnormal heating.

(e) To reduce to a minimum the errors due to time lag between the temperature of the transformers and the variations in the ambient temperature, the thermocouples, or thermometers, shall be placed in suitable containers which shall have such proportions as will require not less than 2 hours for the indicated temperatere within the

The AIEE Project Group on Methods of Making Temperature Rise Tests on Transformers is composed of the following: J. E. Clem, *Chairman;* J. A. Adams; M. F. Beavers; H. B. Keath; A. J. Maslin; W. H. Mutchler; S. O. Schamberger; W. C. Whitman; Paul Narbut and R. C. Smith, alternates.

container to change 6.3 degrees centigrade if suddenly placed in air which has a temperature 10 degrees centigrade higher, or lower, than the previous steady-state indicated temperature within the container.

(f) The temperature rise of metal parts (other than the winding conductor) in contact with, or adjacent to, insulation, and of other metal parts, shall be determined by thermocouple or by thermometer.

(1) Provision shall be made to measure the surface temperature of iron or alloy parts surrounding or adjacent to the outlet leads or terminals carrying large currents. Readings shall be taken at intervals or immediately after shutdown.

(2) The determination of the temperature rise of metal parts within the case, other than winding conductors, is a design test and shall be made when so specified unless a record of this test made on a duplicate, or essentially duplicate, unit can be furnished. This test will not be made unless definitely specified because provision for the proper placement of the thermocouples and leads must frequently be made during the design of the transformer. Comparisons with other transformers having metal parts of similar design and arrangement, but not necessarily having the same rating, will in many cases be adequate.

(g) A thermocouple is the preferred method of measuring surface temperature. When used for this purpose, the thermocouple should, when practical, be soldered to the surface. When this is not practical, the thermocouple should be soldered to a thin metal plate or foil approximately 1 square inch. The plate is to be placed and held firmly and snugly against the surface. In either case, the thermocouple should be thoroughly insulated thermally from the surrounding medium.

(h) The temperature rise of the windings shall be determined by the resistance method, or by thermometer when so specified.

(i) It is permissible to shorten the time required for the test by the use of initial overloads, restricted cooling, or any other suitable method.

(j) The ultimate temperature rise of the winding over the ambient temperature is considered to be constant when the temperature rise of the winding does not change more than 2.5 per cent of the ultimate temperature rise of the winding during a consecutive 3-hour period.

22.520. Determination of Average Measured Winding Temperature by the Hot-Resistance Method

The average measured temperature of a copper winding may be determined by either of the following equations:

$$\theta=\frac{R}{R_0}(234.5+\theta_0)-234.5 \qquad \text{Eq. 22.520–1}$$

$$\theta=\frac{R-R_0}{R_0}(234.5+\theta_0)+\theta_0 \qquad \text{Eq. 22.520–2}$$

θ = temperature in degrees centigrade corresponding to hot resistance R.

θ_0 = temperature in degrees centigrade corresponding to cold resistance R_0.

R_0 = cold resistance determined in accordance with the rules in this standard.

R = hot resistance. Record the elapsed time between the instant of shutdown and each hot resistance measurement.

The induction time for the measuring current to become stable should be noted during the cold-resistance measurements in order to assure that sufficient time elapses for the induction effect to disappear before hot resistance readings are taken.

When transferring the measuring leads from one winding to another, maintain the same relative polarity with regard to the measuring leads and the transformer terminals.

22.525. Temperature Rise Tests—Oil-Immersed Transformers—General

(a) The Short-Circuit Method is the preferred method and shall normally be used for oil-immersed transformers. Any applicable method listed in this Standard may be used when specified or agreed upon.

(b) The top oil temperature shall be measured by a thermocouple or alcohol thermometer immersed approximately 2 inches below the top oil surface.

(c) The average temperature of the oil shall be determined when it is to be used.

These revisions in the American Standards for Transformers have been proposed by the AIEE Committee on Transformers and approved by the AIEE Standards Committee for submission to the American Standard Association (ASA) Sectional Committee C57. The Test Code Subcommittee of ASA C57 has also approved these proposed revisions for inclusion in a revised edition of ASA C57.22 when other revisions now being considered are ready.

The average oil temperature is equal to the top-oil temperature minus one-half the difference in temperature of the moving oil at the top and the bottom of the cooling means, as determined by suitable measurements.

For transformers with external cooling means, this temperature difference may be closely approximated by careful determination of the temperature on the external surface of the oil inlet and oil outlet of the cooling means by the use of thermocouples.

22.530. Temperature Rise Tests on Oil-Immersed Self-Cooled (Class OA) and Self-Cooled/Forced-Air Cooled (Class OA/FA) Transformers

(a) The ambient temperature shall be taken as that of the surrounding air which should be not less than 10 degrees centigrade or more than 40 degrees centigrade.

(b) No corrections for variations of ambient temperature within this range shall be applied.

(c) Temperature tests may be made with ambient temperature outside the range specified, if suitable and agreed upon correction factors are available.

(d) For the forced-air-cooled rating, the cooling air shall be shut off when the load is removed for making the hot-resistance measurements.

22.535. Temperature Rise Tests on Oil-Immersed Water-Cooled (Class OW) Transformers

(a) The quantity of cooling water in gallons per minute

and the temperature of the ingoing and outgoing water shall be determined.

(b) The ambient temperature shall be taken as the temperature of the ingoing water which should preferably be 25 degrees centigrade. It should not be less than 20 or more than 30 degrees centigrade.

(c) No correction for variation of ambient temperature in this range shall be made.

(d) Temperature tests may be made with ambient temperature outside the range specified if suitable and agreed upon correction factors are available.

(e) The cooling water shall be shut off when the load is removed for taking the hot resistance measurements.

22.540. Temperature Rise Tests on Oil-Immersed Forced-Oil-Cooled (Class FOA and FOW) Transformers

(a) The quantity of oil circulated in gallons per minute and temperature of the ingoing and outgoing oil shall be determined. This is not required when the oil circulating equipment is an integral part of the transformer equipment.

(b) If the circulating oil is cooled by air (*FOA*), follow *22.530.*

(c) If the circulating oil is cooled by water (*FOW*), follow *22.535.*

(d) The oil pumps shall be shut down simultaneously with the removal of the load for the measurement of the hot resistance.

22.545. Temperature Rise Tests on Oil-Immersed Water-Cooled/Self-Cooled (Class OW/A) Transformers

(1) These transformers shall be tested according to self-cooled or water-cooled rules depending upon the method of cooling used in the test.

22.550. Temperature Rise Test on Oil-Immersed Transformers by the Short-Circuit Method, Using the Top Oil Temperature Rise

This test shall be conducted as follows:

(a) Determine the top oil temperature rise over the ambient temperature as produced by the total loss at rated output in the following manner:

(1) Short-circuit the high-voltage, or the low-voltage, winding (or windings), and circulate sufficient current at rated frequency through the windings so that the losses in the windings under this condition will equal the required total losses.

(2) The required total losses are defined as being equal to the sum of the excitation loss at rated voltage and frequency, plus the load loss at rated current and frequency; and at an assumed ultimate average temperature of the winding equal to the rated temperature rise plus 20 degrees centigrade.

(3) Run until top-oil temperature rise over the ambient temperature becomes constant.

(b) Determine the average temperature rise of the winding over the top oil temperature in the following manner:

(1) Immediately after determining the top-oil temperature rise as described above, adjust the currents in the windings to the rated values for the temperature-test connection and hold them constant for 2 hours. Then shut down and measure the winding resistance and calculate the average winding rise over the top oil temperature at the end of the 2-hour run.

(2) Correct these rises back to the instant of shutdown.

(3) Multiwinding transformers may require additional runs to determine the average winding temperature rises over top oil for all windings.

(c) The average winding temperature rise over ambient temperature is the sum of the top-oil temperature rise over the ambient temperature, plus the average winding temperature rise over the top oil temperature.

22.555. Temperature Rise Test on Oil - Immersed Transformers by the Short-Circuit Method, Using the Average Oil Temperature Rise

This test shall be conducted as follows:

(a) Determine the average oil temperature rise over the ambient temperature as produced by the total loss at rated output in the following manner:

(1) Short-circuit the high-voltage, or the low-voltage, winding (or windings), and circulate sufficient current at rated frequency through the windings so that the losses in the windings under this condition will equal the required total losses.

(2) The required total losses are defined as being equal to the sum of the excitation loss at rated voltage and frequency, plus the load loss at rated current and frequency, and at an assumed ultimate average temperature of the winding equal to the rated temperature rise plus 20 degrees centigrade.

(3) Run until top-oil temperature rise over the ambient temperature becomes constant.

(b) Determine the average temperature rise of the winding over the average oil temperature in the following manner:

(1) Immediately after determining the average oil temperature rise as described above, adjust the currents in the windings to the rated values for the temperature-test connection and hold them constant for 2 hours. Then shut down and measure the winding resistances and calculate the average winding rise over the average oil temperature at the end of the 2-hour run.

(2) Correct these rises back to the instant of shutdown.

(3) Multiwinding transformers may require additional runs to determine the average winding temperature rises over the average oil temperature for all windings.

(c) In determining the average winding rise over the average oil temperature, it is permissible, unless specified otherwise, for the winding currents to deviate from the rated values. The actual current in any winding under test shall not be less than 85 per cent of the rated current of that winding.

(d) When the current held in any of the windings under test differs from the rated current, the observed average winding temperature rise over the average oil temperature may be corrected to give the average temperature rise of

the windings corresponding to the rated current, using the following formula:

$$\text{CTR} = \text{OTR}\left(\frac{\text{Rated Current}}{\text{Test Current}}\right)^{1.6} \qquad \text{Eq. 22.555}^{d}$$

where CTR is the corrected average temperature rise of the winding above the average temperature of the oil, and OTR is the observed average temperature rise of the winding above the average temperature of the oil.

(e) The average winding temperature rise over the ambient temperature is the sum of the average oil temperature rise over the ambient temperature, plus the corrected average winding temperature rise over the average oil temperature.

22.556. Temperature Rise Test on Oil-Immersed Transformers by the Loading Back Method

(a) Single-Phase Transformers

(1) Duplicate single-phase transformers may be tested by the load-back method by connecting both the high-voltage and the low-voltage windings in parallel, and by applying rated excitation voltage at rated frequency to one set of paralleled windings (Figure 22.101a, as renumbered).

(2) Circulate load current by opening the connections of either pair of windings at one point and impress a voltage across the break just sufficient to circulate rated currents through the windings. This current should preferably (but not necessarily) be at rated frequency.

(3) Run until the top-oil rise over the ambient temperature is constant.

(4) Then shut down, measure the winding resistance, and calculate the average winding rises over the ambient temperature.

(5) Correct these rises back to instant of shutdown.

(b) Three-Phase Transformers

(1) Duplicate 3-phase transformers may be tested by the load-back method by connecting both the high-voltage and low-voltage windings in parallel (Figure 22.100d, as renumbered). (It is desirable to connect similarly marked leads together rather than attempt to connect windings in parallel by symmetry alone.) Rated excitation voltage at rated frequency should be applied to one set of the windings.

(2) Circulate rated current by joining either set of windings through an auxiliary source of 3-phase loading voltage (Figure 22.100d, as renumbered). The circulated current should preferably (but not necessarily) be at rated frequency.

(3) Run until the top-oil rise over the ambient temperature is constant.

(4) Then shut down, measure the winding resistance, and calculate the average winding rises over the ambient temperature.

(5) Correct these rises back to the instant of shutdown.

(c) If the frequency of the circulated current is other than rated frequency, the load losses may differ from those obtained under rated frequency conditions and a correction for the top oil rise and for the winding rise may be required. This correction may be made by one of the following methods, provided the loading frequency does not differ from the rated frequency by more than 10 per cent.

(1) By calculation

$$\underset{\text{correction}}{\theta_c = \text{Oil rise}} = \underset{\text{oil rise}}{\text{Observed}} \times \left\{\left(\frac{W}{w}\right)^{0.8} - 1\right\} \qquad \text{Ep. 22.556(c)}$$

W = required loss

w = actual loss

Corrected top oil rise = observed top oil rise plus θ_c

Corrected winding rise = observed winding rise plus θ_c

This method should be used only when the actual loss (w) is within 20 per cent of the required loss (W).

(2) By adjusting the losses

When the top-oil rise approaches a constant condition, adjust the excitation voltage until the sum of the excitation loss and the load loss as measured during the temperature test equals the required loss. Run until the top-oil rise is constant.

22.560. Temperature Rise Tests—Dry-Type Transformers—General

(a) When the ambient air temperature is other than 30 degrees centigrade, a correction shall be applied to the temperature rise of the winding by multiplying it by the correction factor C which is given by the ratio

$$C = \frac{264.5}{234.5 + \theta} \qquad \text{Eq. 22.560(a)}$$

in which θ is the ambient air temperature.

(b) When temperature rise tests by thermometer are required, place at least one alcohol thermometer in each high- and low-voltage group of coils. If the respective coil groups consist of several coils, several thermometers should be placed in each group. It is important that the coil thermometers be properly placed in the air ducts in such a manner as to indicate the winding temperature and yet not restrict the ventilation. This may be accomplished by means of grooved sticks of dry wood or some other kind of insulating material slightly larger than the thermometer bulbs.

When the thermometers are used for measuring temperatures of apparatus other than oil-immersed, the bulbs shall be covered by felt pads cemented to the equipment. When pads interfere with ventilation, as in ventilating ducts between coils, grooved wooden sticks may be used.

Dimensions of felt pads for use with large apparatus shall be $1^1/_2$ by 2 by 1/8 inches.

(c) When the temperature rise has become constant, the test voltage and current should be removed and the blowers, if used, shut off. Immediately thereafter the coil thermometers and any other temperature-indicating devices should be read continually in rotation until the temperature begins to fall. If any of the thermometer temperatures are higher than those observed during the run, the highest temperature should be recorded as the final thermometer temperature.

22.565. Temperature Rise Tests on Dry-Type Self-Cooled (Class AA) Transformers

(1) The ambient temperature shall be taken as that of the surrounding air which should be not less than 10 degrees centigrade nor more than 40 degrees centigrade.

22.570. Temperature Rise Tests on Dry-Type Forced-Air-Cooled (Class AFA) Transformers, Separately Mounted Blower

(a) The quality of cooling air in cubic feet per minute and the temperature of the ingoing and outgoing air shall be determined.

(b) The ambient temperature shall be taken as that of the ingoing air and shall be not less than 10 degrees centigrade nor more than 40 degrees centigrade.

22.575. Temperature Rise Tests on Dry-Type Forced-Air-Cooled (Class AFA) Transformers, Integral Blower

(a) The ambient temperature shall be taken as that of the ingoing air and shall not be less than 10 degrees centigrade nor more than 40 degrees centigrade.

22.580. Temperature Rise Tests on Dry-Type Transformers

Methods of making temperature rise tests on dry-type transformers are currently under analysis and development. It is suggested that, when possible, the load-back method be used.

22.585. Correction Back to Shutdown, Empirical Method

(a) The empirical method utilizes correction factors which represent average results from usual commercial designs. This method is not to be used for forced-oil-cooled transformers, nor for those designs which deviate considerably from usual commercial proportions. In such cases, the cooling curve method should be used.

(b) Take one hot-resistance reading on each winding, record the time after shutdown, and determine the corresponding temperature rise.

(c) All hot-resistance readings shall be completed within 4 minutes after shutdown. If this cannot be accomplished, the temperature test shall be resumed until normal temperatures are again obtained, after which the remainder of the readings should be taken.

(d) When the copper loss of oil-immersed transformers does not exceed 30 watts per pound, the correction in degrees centigrade, to be added to the measured temperature rise, may be taken as the product of the watts per pound of copper by the empirical factor given in Table 22.585(d).

Table 22.585(d)

Time After Shutdown, Minutes	Factor
1	0.19
1.5	0.26
2	0.32
3	0.43
4	0.50

For intermediate times, the values of the factor may be obtained by interpolation.

(e) When the copper loss of oil-immersed apparatus does not exceed 7 watts per pound, an arbitrary correction of 1 degree centigrade per minute may be used.

(f) The copper loss in watts per pound in a winding shall be taken as the sum of the calculated I^2R and eddy current loss at a temperature equal to the rated temperature rise plus 20 degrees centigrade.

22.590. Correction Back to Shutdown, Cooling Curve Method

(a) Take a series of at least four, preferably more, readings on one phase of each winding, and record the time after shutdown for each reading. The readings should be time spaced to assure accurate extrapolation back to shutdown. The over-all reading time should exceed 4 minutes and may extend considerably beyond.

(b) The first reading on each winding should be taken as quickly as possible after shutdown, but not before the measuring current has become stable, and must be taken within 4 minutes.

(c) Plot the resistance time data on suitable co-ordinate paper and extrapolate the curve back to instant of shutdown.

(d) The resistance value so obtained shall be used to calculate the average winding temperature at instant of shutdown.

(e) The resistance time curve obtained on one phase of the primary winding, or of the secondary winding, and so forth, may be used to determine the correction back to shutdown for the other phases of the primary or secondary, windings, and so forth, provided the first reading on each of the other windings has been taken within 4 minutes after shutdown.

(f) If necessary the temperature test may be resumed so that the first readings on any group of windings may be completed within the required 4 minutes.

22.595. Correction of Observed Temperature Rise for Variation in Altitude

(a) When tests are made at an altitude not exceeding 3,300 feet (1,000 meters) above sea level, no altitude correction shall be applied to the temperature rise.

(b) When a transformer which is tested at an altitude less than 3,300 feet is to be operated at an altitude in excess of 3,300 feet, it shall be assumed that the observed temperature rise will increase in accordance with the following relation:

$$\text{Increase in temperature rise at altitude } A \text{ (feet)} = \text{Observed rise} \times \frac{(A-3{,}300)}{330} F$$

where F is an empirical factor given in Table 22.595(b).

Table 22.595(b)

Type of Transformer	Empirical Factor F
For oil-immersed, self-cooled (*OA*)	0.004
For dry-type, self-cooled (*AA*)	0.005
For oil-immersed: with auxiliary (*OA/FA*) and dry-type: forced air cooling (*AA/FA*)	0.006*
For dry-type forced-air cooled (*AFA*)	0.010

* Applies to forced-cooled rating only.

The "Observed Rise" in the foregoing equation is:

Top Oil Rise, or Average Oil Rise, over the ambient temperature for oil-immersed transformers

Winding Rise over the ambient temperature for dry-type transformers.

(c) The winding rise for oil-immersed transformers over ambient at altitude A is the observed winding rise over ambient plus the calculated increase in temperature rise.

Winter General Meeting Will Feature Largest Program in Institute History

The 1953 Winter General Meeting, to be held at the Hotel Statler and the Engineering Societies Building in New York, N. Y., January 19–23, will feature the largest technical program in the history of the Institute. The social activities, for which the Winter Meetings are noted, will again be one of the outstanding features. A group of inspection trips has also been arranged, closely allied with the technical sessions and conferences.

Dr. H. T. Heald, Chancellor of New York University, will deliver the principal address at the general session to be held at 2:00 p.m., Monday, January 19. Dr. Heald, recently installed as Chancellor, will speak on a subject most timely in this transition period of national and world events. At this session also, the Edison Medal will be presented to Dr. V. K. Zworykin and the Institute Paper Prizes will be presented. President D. A. Quarles will preside.

Social events will include a dinner-dance, smoker, an informal tea, theater tickets for out-of-town members, and special entertainment for the ladies.

A feature of this year's Winter General Meeting will be the Western Union Telegraph Company's installation of facsimile telegraph equipment for the convenience of those attending the meeting who wish to communicate immediately with offices and families back home. The telegraph equipment used will be the Desk-Fax, a miniature sending and receiving apparatus by means of which the telegram is received as a "picture" of the sent message and arrives ready for immediate use. Several papers on the latest communication techniques are scheduled for presentation by Western Union engineers at the meeting.

Another technical session which promises to be of interest is that planned by the Committee on Telegraph Systems on the subject of wire and cable for use in the telegraph industry. The modern mechanized communication center contains some 3,000 miles of wire conductors and more than 1,000,000 intricate wire connections. The session will describe new standards of insulation and operating efficiency which have been achieved with reduced weights and diameters under adverse conditions of humidity and temperature. In addition, there will be an interesting description of a new nonarmored submarine telegraph cable having the necessary tensile and compressive strength with a weight less than one-fifth that of steel-armored cable heretofore used.

ELECTRICAL SAFETY IN HOSPITALS

How to prevent explosions from static in hospital operating rooms will be demonstrated by P. G. Guest, electrical engineer of the United States Bureau of Mines.

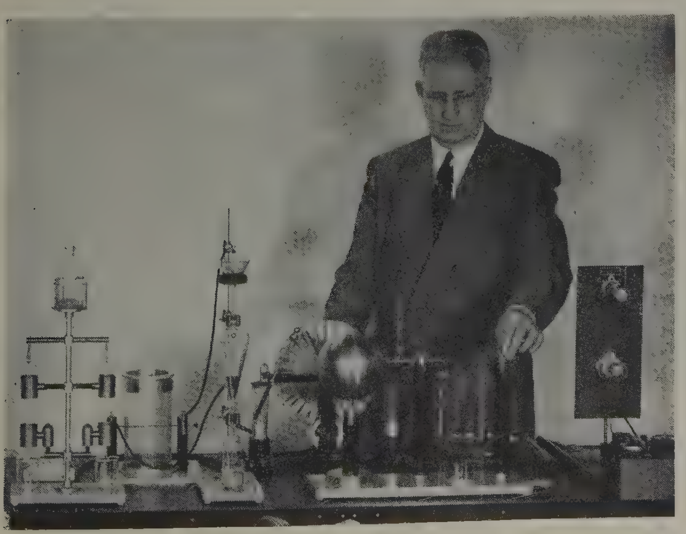
Mr. Guest's series of scientific demonstrations will be part of a session promoting electrical safety in hospitals on January 21 sponsored by the Safety Committee of the Institute. Complementing the demonstration will be papers dealing with special considerations of operating room safety. These will be presented by Dr. C. W. Walter, of Boston's Peter Bent Brigham Hospital, and Robin Beach, authority on static electricity.

To show that static creates dangerous hazards in operating rooms and ways in which they can be overcome, Mr. Guest's hour-long demonstration requires more than 300 pounds of especially designed laboratory apparatus. This includes a miniature operating table, samples of rubberized fabric, synthetic fabrics, cotton, and other materials used in operating rooms, several types of explosion vessels, an "electric chair," mercury shower static machine, nylon stockings, aspirator bulb, and many sensitive detecting instruments. While most of the demonstrations are dramatic, their purpose is not to frighten, but to help electrical engineers, doctors, and hospital personnel understand just what causes static in operating rooms and what can be done about it.

In addition to this operating room safety session during the afternoon of January 21, a special panel discussion on safe electrical grounding will be conducted at a morning session by the Safety Committee.

HOTEL RESERVATIONS

Blocks of rooms have been set aside at the Hotel Statler (meeting headquarters) and nearby hotels for members and guests



Causes and cures of explosions from static in hospital operating rooms will be shown in a series of scientific demonstrations at the Winter Meeting. P. G. Guest is shown adjusting his apparatus for revealing the effects of circuit capacitance and length of spark on the ignition of anesthetic gases and vapors

Future AIEE Meetings

AIEE-IRE-NBS Conference on High-Frequency Measurements
Statler Hotel, Washington, D. C.
January 14–16, 1953

Winter General Meeting
Statler Hotel, New York, N. Y.
January 19–23, 1953
(*Final date for submitting papers—closed*)

Southern District Meeting
Seelbach Hotel, Louisville, Ky.
April 22–24, 1953
(*Final date for submitting papers—January 22*)

North Eastern District Meeting
Sheraton Plaza Hotel, Boston, Mass.
April 29–May 1, 1953
(*Final date for submitting papers—January 29*)

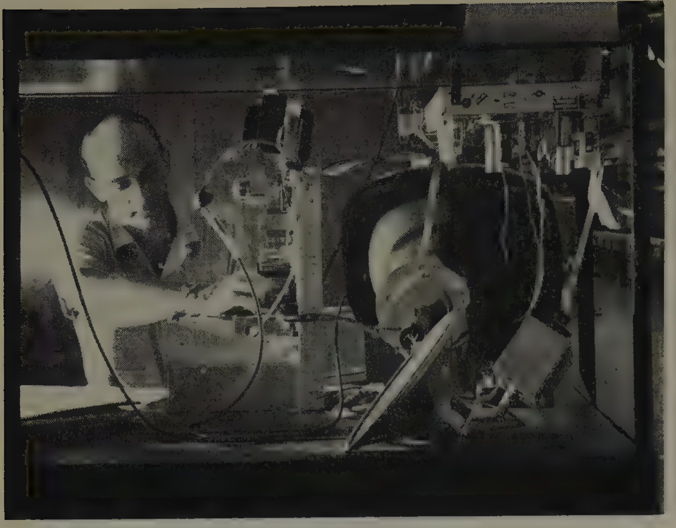
Summer General Meeting
Chalfont-Haddon Hall Hotel, Atlantic City, N. J.
June 15–19, 1953
(*Final date for submitting papers—March 17*)

Pacific General Meeting
Hotel Vancouver, Vancouver, British Columbia, Canada
September 1–4, 1953
(*Final date for submitting papers—June 3*)

Middle Eastern District Meeting
Daniel Boone Hotel, Charleston, W. Va.
September 29–October 1, 1953
(*Final date for submitting papers—June 30*)

Fall General Meeting
Muehlebach Hotel, Kansas City, Mo.
November 2–6, 1953
(*Final date for submitting papers—July 6*)

An innovation this year is an Informal Tea which will be held on Sunday afternoon, January 18 from 4 to 6 p.m. in the Georgian Room of the Statler. Members and their guests are invited to participate in this gathering prior to the start of the formal program. There will be no charge. During the same period the registration facilities will be open for those wishing to avoid the Monday morning rush.



Visitors taking the Wednesday afternoon tour of the Du Mont Television Receiver Manufacturing Plant at East Paterson, N. J., will see operations such as the testing of television receiving chassis shown here

attending the meeting. Requests for reservations should be sent prior to January 9, directly to the hotel of choice, and to only one hotel. AIEE should be mentioned in the request and a copy sent to W. G. Vieth, Chairman, Hotel Accommodations Committee, Western Union Telegraph Company, 60 Hudson Street, New York 13, N. Y. A second and third choice should be noted on this copy.

Due to the current accommodations situation in New York hotels, reservations for arrival on Sunday, January 18, are suggested. If the accommodations at the hotel requested are not available, the Hotel Accommodations Committee will transfer the request to one of the other hotels on the list.

Rooms have been reserved at the following conveniently located hotels:

Hotel Statler (meeting headquarters), 7th Avenue, 32d to 33d Streets

Single room with bath	$ 5.00 to $10.00
Double room, double bed	8.00 to 12.50
Double room, twin beds	9.00 to 17.00
Studio type	12.00 to 18.00
Parlor Suites	22.00 to 40.00

Hotel Governor Clinton, 7th Avenue at 31st Street

Single room with bath	$ 5.50 to $ 7.00
Double room, double bed	8.00 to 9.50
Double room, twin beds	9.00 to 11.00

Hotel McAlpin, Broadway and 34th Street

Single room with bath	$ 5.00 to $ 9.00
Double room, double bed	8.00 to 13.00
Double room, twin beds	9.00 to 13.00

New Yorker Hotel, 34th Street and 8th Avenue

Single room, tub and shower	$ 5.50 to $ 8.00
Double room, double bed	8.50 to 12.50
Double room, twin beds	9.50 to 14.00

Hotel Martinique, Broadway and 32d Street

Single room with bath	$ 5.00 to $ 7.00
Double room, double bed	8.00 to 10.00
Double room, twin beds	8.50 to 11.00

Hotel Commodore, 42d Street at Lexington Avenue

Single room with bath	$ 6.00 to $10.00
Double room, double bed	10.00 to 12.50
Double room, twin beds	11.50 to 14.50

Hotel Roosevelt, Madison Avenue at 45th Street

Single room with bath	$ 7.50 to $10.50
Double room, double bed	13.00 to 16.00
Double room, twin beds	14.00 to 18.00

Rates are subject to 5 per cent New York City hotel room tax.

INSPECTION TRIPS

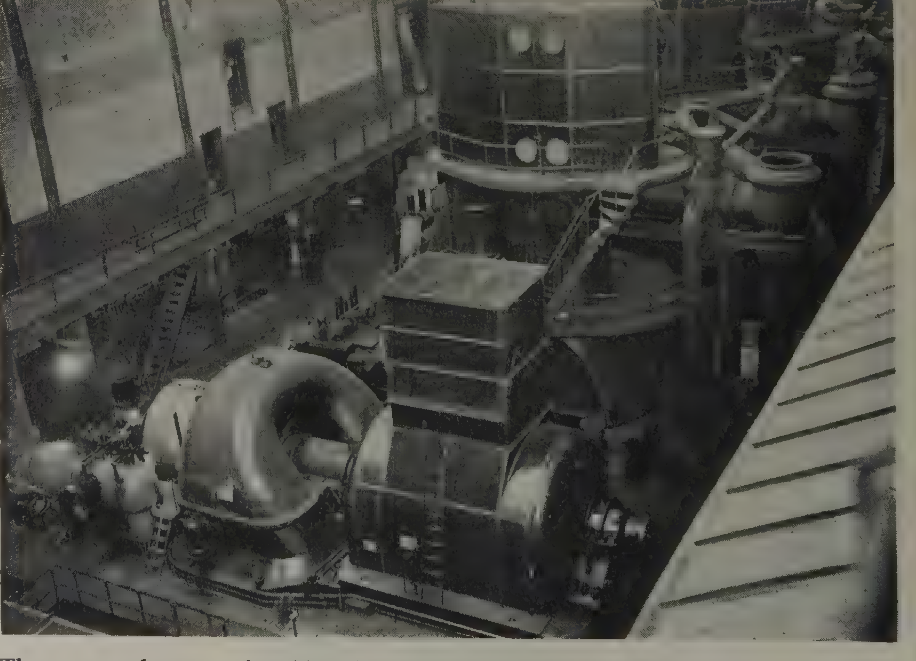
A program of inspection trips of both technical and general interest has been arranged for those attending the Winter General Meeting. Since the number of people who may be accommodated on all of these trips is limited, members who are interested are urged to make arrangements and obtain full details at the Inspection Trips Desk immediately after registering at meeting headquarters. Advance registration by mail for trips cannot be accepted. On some of the trips, proof of United States citizenship will be required, and members should be prepared to comply with such security regulations as may be in force at the time of the trip.

Radio City Music Hall, New York, N. Y. (Tuesday morning, January 20). This ever-popular trip has again been scheduled, for the fourth year, as a result of many requests. Spectacular stage shows distinguished by unique lighting effects have made Radio City Music Hall an outstanding attraction for visitors from all over the world. Members will see the back-stage facilities as well as unusual features such as the revolving sectionalized stage, elevating orchestra pit, motorized curtains, and the multitude of electric and mechanical controls required for the special stage and theater lighting effects. The magnitude of these operations is indicated by the connected load of 5,500 horsepower in motors and 3,500 kw of lighting.

National Biscuit Company, New York, N. Y. (Tuesday morning, January 20). An opportunity to visit the largest manufacturing plant on Manhattan Island will be afforded members by the National Biscuit Company which markets over 500 different varieties of bakery products, such as crackers, pretzels, ice cream cones, waffles, and dog biscuits. The New York plant covers 52 acres of floor space and is the largest of their 43 bakeries located throughout the country. Automatic packaging machinery, as well as hand-packing operations, will be seen, in addition to a variety of electronic control and registering applications.

International Business Machines, New York, N. Y. (Tuesday afternoon, January 20, and Thursday and Friday mornings, January 23 and 24). Great progress has been made in recent years in the field of electronic calculators, which combine the speed of the electric circuit with a memory capacity for thousands of digits. Many complex scientific and engineering problems are solved today in this manner in a bare fraction of the time formerly required. Technical personnel of International Business Machines, a pioneer in the field of labor-saving devices, will explain the operation of their recently developed Selective Sequence Electronic Calculator and will exhibit and explain numerous other electronic devices such as their 4-unit calculator.

Board of Transportation, City of New York, 59th Street Power Plant, New York, N. Y. (Tuesday afternoon, January 20, and Friday



The contrast between the old and the new, a 35,000-kw turbine-generator against a background of 7,500-kw Corliss steam-engine-driven generators, is shown at the 59th Street Power Plant of the New York City Board of Transportation, scheduled for inspection during the Winter General Meeting

morning, January 23). An unusual opportunity will be provided to see in close contrast the very new and the very old in generating equipment. A 7,500-kw cross-compound Corliss engine with its 35-foot diameter generator rotor represents the very old, while the new equipment consists of a 50,000-kw high-pressure turbine with a hydrogen-cooled generator and the latest in associated switchgear and controls. An air-conditioned electric control room is a feature of this unique installation.

United Nations General Assembly Hall, New York, N. Y. (Tuesday afternoon, January 20, and Thursday morning, January 22). Completed in October 1952, this is the last of the three principal buildings which comprise the $68,000,000 permanent headquarters of the United Nations. The latest in modern design, it is distinguished by unusual lighting effects and acoustical treatments designed by outstanding authorities. A complex communication system enables listeners to hear a speech, as it is being given, in any one of six languages by a twist of a dial. Representatives of the consulting engineers who worked on the design of the electric and mechanical equipment in the building will be on hand to explain the many interesting features.

Harbor Radar Installation of the Port of New York Authority, Fort Wadsworth, Staten Island, N. Y. (Wednesday morning, January 21). A limited number of members will be permitted to view the equipment and witness a demonstration of the operation of the experimental radar installation whose purpose is to identify and control ship traffic in New York Harbor.

Du Mont Television Receiver Manufacturing Plant, East Paterson, N. J. (Wednesday afternoon, January 21). An opportunity to see the manufacturing techniques and methods employed in turning out television receivers in quantity will be offered AIEE visitors. This plant was placed in operation in the fall of 1948, and is one of the largest in the United States. This tour promises to be a rare treat to those interested in the complex interior of a modern television set.

Part of the extensive automatic equipment designed by Bell Telephone Laboratories for use in the nation-wide subscriber long-distance dialing system are these message accounting perforators set up for test purposes. The Laboratories will be the subject of a Winter Meeting inspection trip

Rambusch Decorating Company, Lighting Division, New York, N. Y. (Wednesday afternoon, January 21). Founded in 1890, the Rambusch Decorating Company has progressed from its original field of church painting to its present status as an outstanding specialist in the design and manufacture of ornamental and engineered lighting equipment. Here visitors will find, under one roof, such diversified crafts as mural painting, sculpture, stained glass window design, cabinet making, and metal shops, as well as those involved in the production of special lighting fixtures. This trip should prove to be an unusual experience to members with artistic interests.

United States Naval Supply Depot (Wednesday, all day, January 21). Visitors will see the United States Naval Salvage School, the only one of its kind in the world where underwater welding and arc-oxygen cutting are used. Some of the vessels of the Atlantic Reserve Fleet, including the *Franklin* and the *Enterprise*, will be open to inspection. The tour of the Naval Shipyard will include the drydock and associated equipment capable of handling the largest ship afloat. Many other unusual facilities to be shown to the group will be high-frequency cooking equipment, a submarine galley, and various laboratory testing equipment.

On the inspection trip to the Brookhaven National Laboratory, Upton, N. Y., members will see the Cosmotron, shown here from approximately the angle at which atomic particles, protons, enter the machine. The steel tank (lower left) houses the Van de Graaf generator

Brookhaven National Laboratory, Upton, Long Island, N. Y. (Thursday, all day, January 22). The facilities at this location are operated by Associated Universities, Inc., under contract with the Atomic Energy Commission, and constitute the northeastern center for nuclear research and development in the fields of physics, chemistry, biology, medicine, and engineering. Among the important exhibits are the atomic pile model, cloud chamber, 60-inch cyclotron, Van de Graaf electrostatic accelerator, and the Cosmotron. A complete tour has been arranged with competent guides, and engineers and scientists will be on hand to explain fully the extensive facilities and exhibits which have been erected at this vast site.

Anheuser-Busch, Inc., Newark, N. J. (Thursday afternoon, January 22). The brewers of world-famous Budweiser beer offer a tour through their brand-new plant, built "from the ground up" to their own design and specifications. The buildings are of completely modern construction both outside and inside, and contain the finest electric and mechanical equipment and controls obtainable for processing operations of this nature.

Bell Telephone Laboratories, New York, N. Y. (Thursday afternoon, January 22). On this trip lectures and demonstrations will be given on switching apparatus, the

(*Continued on page 83*)

Tentative Technical Program

Winter General Meeting, New York, N. Y., January 19-23

Monday, January 19

10:00 a.m. Land Transportation

CP. Trends in Rapid Transit Car Design.** *S. H. Bingham*, New York City Board of Transportation

CP. Extension of Rapid Transit Facilities in Boston.** *S. B. Lent*, Metropolitan Transit Authority

CP. Development of Rapid Transit and Superhighways in Chicago.** *S. D. Forsythe*, Chicago Transit Authority

53-35. An Interurban Becomes a Railroad. *C. H. Jones*, Chicago, South Shore and South Bend Railroad

10:00 a.m. Insulated Conductors

53-28. Development of Training and Jointing Techniques to Prolong the Life of Lead Cable Sheath. *G. H. Fiedler, E. J. Nelson*, Rochester Gas and Electric Corporation

53-33. Gencalloy A Lead Alloy Cable Sheath Creep and Fatigue Characteristics. *R. W. Atkinson, L. Meyerhoff, W. H. Cortelyou*, General Cable Corporation

53-59. The Microbiological Deterioration of Rubber Insulation. *J. T. Blake, D. W. Kitchin, O. S. Pratt*, Simplex Wire and Cable Company

10:00 a.m. Electric Circuit Theory

53-60. A Graphical Method for Flip-Flop Design. *R. F. Johnson, A. G. Ratz*, University of Toronto

53-61. Analysis of a Comb Filter Using Synchronously Commutated Capacitors. *W. R. LePage, C. R. Cahn, J. S. Brown*, University of Syracuse

53-62. The Rayleigh Method in Network Calculations. *F. W. Schott, Jack Heilfron*, University of California

CP. Block Diagram Solutions for Vacuum Tube Circuits.** *T. M. Stout*, University of Washington

53-64–ACO.* Phase Plane Characterization of a Nonlinear Inductance. *H. E. Ellithorn*, University of Notre Dame; *William Shewan*, Valparaiso University; *Kenneth Kempf*, University of Notre Dame

10:00 a.m. Industrial Power Systems

CP. Equipment Grounding for Industrial Plants.** *L. J. Carpenter*, General Electric Company

CP. Short-Circuit Protection for Small and Medium-Size Industrial Plant Generators.** *F. L. Brightman*, General Electric Company

CP. The Effect of Iron Conduit on Single-Phase Circuit Impedance.** *E. A. Rockau*, Consolidated Edison Company of New York, Inc.

CP. Problems Associated With the Installation and Operation of a 6,900-Volt Grounded Neutral Industrial Power System.** *C. L. Eichenberg*, Bethlehem Steel Company

10:00 a.m. Electronic Power Converters and Substations

53-24. Capacitors in Power Systems With Rectifier Loads. *A. Schmidt, Jr.*, General Electric Company

53-65. Load Dropping Tests on a Large Ignitron Rectifier Installation. *S. J. Pope*, Kaiser Aluminum and Chemical Corporation; *J. K. Dillard, C. R. Marcum*, Westinghouse Electric Corporation

53-66–ACO.* Industrial Electronic Rectifiers for Essential Service Duty. *M. E. Reagan*, Westinghouse Electric Corporation

53-26. Magnetic Amplifier Applications in D-C Conversion Stations. *W. A. Derr, E. J. Cham*, Westinghouse Electric Corporation

53-67. Oil-Immersed 110-Kv 440-Kw Rectifier Unit for Resnatron Plant Supply. *R. P. Featherstone, Cheng Ling, P. A. Cartwright*, University of Minnesota

* ACO: Advance copies only available; not intended for publication in *Transactions*.

** CP: Conference paper; no advance copies are available; not intended for publication in *Transactions*.

—PAMPHLET reproductions of authors' manuscripts of the numbered papers listed in the program may be obtained from AIEE Order Department, 33 West 39th Street, New York 18, N. Y., as noted in the following paragraphs.

—PRICES of papers, irrespective of length, are 30 cents to members (60 cents to nonmembers) whether ordered by mail or purchased at the meeting. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in nine-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the Technical Program Committee ultimately will be published in the bimonthly publications and Transactions; also, each is scheduled to be published in Electrical Engineering in digest or other form.

10:00 a.m. Conference on Education

Panel Discussion: Should Curriculum Options Continue? by G. S. Brown, Massachusetts Institute of Technology; K. B. McEachron, Jr., General Electric Company; J. R. North, Commonwealth Associates, Inc

10:00 a.m. Conference on Applied Mathematics

CP. Induced Potentials.** *Garrett Birkhoff*, Harvard University

CP. The Optimum Characteristic of a Nonlinear Device for Producing Combination Frequencies.** *W. H. J. Fuchs*, Cornell University

CP. The Theory of Queues.** *D. G. Kendall*, Oxford and Princeton Universities

53-29. A Mathematical Analysis of a Series Circuit Containing a Nonlinear Capacitor. *L. A. Pipes*, University of California

10:00 a.m. Conference on AIEE Standard Number 1

CP. Proposed Revision in AIEE Standard Number 1.** *G. L. Moses*, Westinghouse Electric Corporation

CP. IEC Proposals on Classification of Insulation.** *M. S. Hancock, P. C. Smith*, Westinghouse Electric Corporation

CP. Proposed Test Codes for Functional Evaluation and Insulation Systems for Rotating Machinery.** *P. L. Alger*, General Electric Company

CP. Proposed Test Codes for Functional Evaluation of Insulation and Insulation Systems for Transformers.** *J. L. Cantwell*, General Electric Company

10:00 a.m. Carrier Current

53-165. A Study of Carrier Frequency Noise. Part III—Interpretation of Field Measurements. *J. D. Moynihan, B. J. Sparlin*, Westinghouse Electric Corporation

53-166. A Flexible New Line of Power-Line Carrier Equipment. *F. B. Gunter*, Westinghouse Electric Corporation

CP. Optimum Selectivity for Existing Carrier-Current Pilot Relay Channels.** *D. C. Pinkerton*, General Electric Company

CP. Methods of Rating Carrier-Current Equipment.** *T. A. Cramer*, General Electric Company

53-167–ACO.* Bibliography of Power-Line Carrier Literature. *Subcommittee on Bibliography*

2:00 p.m. General Session

Edison Medal Presentation to Dr. V. K. Zworykin

Establishment of the Edison Medal: Professor J. F. Calvert, Chairman, Edison Medal Committee

Career of the Medalist: Dr. E. W. Engstrom, Vice-President in charge of Research, RCA Laboratories Division, Radio Corporation of America

Presentation of Medal: President D. A. Quarles

Response of the Medalist: Dr. V. K. Zworykin

Presentation of Institute Prizes

Address by Dr. H. T. Heald, Chancellor, New York University

Tuesday, January 20

9:30 a.m. Land Transportation

Introduction. L. S. Billau, Baltimore and Ohio Railroad

CP. The Diesel Locomotive—Its Real Meaning to the Railroads.** *Charles Kerr, Jr.*, Westinghouse Electric Corporation

53-68. Diesel-Electric Locomotives in Canada. *J. D. Sylvester*, Canadian National Railways; *D. F. Haney*, Canadian Pacific Railways

53-69. Electric Transmission With Diesel Locomotives. *P. A. McGee*, Consulting Transportation Engineer

53-70. Education and Training of Diesel-Electric Locomotive Maintenance Personnel. *J. W. Teker, E. R. Ainsworth*, General Electric Company

53-48. Dynamic Braking on Diesel-Electric Locomotives. *A. V. Johansson, H. R. Stiger*, General Electric Company

9:30 a.m. Electric Space Heating and Heat Pumps

CP. Problems of Design in Residential Electric Heating.** *H. B. Wilde*, Wessix Electric Heater Company

CP. Experience With Controlled Electric Space Heating.** *R. G. Giedd*, Florida Power Corporation

CP. Electric Space Heating and Resulting System Load Factors.** *T. H. Allen*, Memphis Light Gas and Water Division

CP. Air-to-Air Heat Pump Systems and Their Calculated Electrical Characteristics.** *P. F. O'Neill*, General Electric Company

53-71. An Analytical Solution of Heat Flow Versus Wire Temperature for Electric Cables Buried in Plaster. *J. E. Goff*, Homes, Inc. Presentation by title only for discussion

9:30 a.m. Maintenance of Rotating Machinery

CP. Commutation Problems.** *C. E. Boesmiller*, Department of Water and Power, City of Los Angeles

CP. Insulation Maintenance Guide for Large A-C Rotating Machinery.** (Subcommittee Report.) *G. L. Moses*, Westinghouse Electric Corporation

CP. Standards for Repair Shops.** *Sam Heller*, Consolidated Electric Motor Company

CP. Maintenance of Large Rotating Electric Equipment on Shipboard.** *W. H. Fifer*, Bureau of Ships

9:30 a.m. Magnetic Materials

CP. The Critical Material Situation for Magnetic Materials.** *F. H. Buttner*, National Research Council

CP. Properties of Bismanol Permanent Magnets.** *Edmund Adams*, Naval Ordnance Laboratories

CP. Magnetic Materials for High-Speed Pulse Circuits.** *D. R. Brown*, Massachusetts Institute of Technology

CP. Stressed Ferrites With Rectangular Hysteresis Loops.** *H. J. Williams*, Bell Telephone Laboratories, Inc.

9:30 a.m. Nucleonics

CP. 70-Megelectron-Volt Medical Synchrotron.** *R. N. Edwards*, General Electric Company

CP. Nuclear Power Reactor.** *John Menke*, N. D. A.

CP. Design Parameters of Beta Thickness Gauges.** *Harrison Faulkner*, Tracerlab, Inc.

CP. New Focus Scheme of the Brookhaven Cosmotron.** *J. P. Blewett*, Brookhaven National Laboratory

CP. A Scintillation Detector With Extended Plateau.** *Earl Farmer*, Tracerlab, Inc.

9:30 a.m. Electronic Power Converters

53-53. Electronic Frequency Changer Used as Non-synchronous Tie Between A-C Power Systems. *Harold Winograd*, Allis-Chalmers Manufacturing Company

53-36. Extended Regulation Curves for 6-Phase Double-Way and Double-Y Rectifiers. *I. K. Dortort*, I-T-E Circuit Breaker Company

53-54. Influence of A-C Reactance on Voltage Regulation of 6-Phase Rectifiers. *R. L. Witzke, J. V. Kresser, J. K. Dillard*, Westinghouse Electric Corporation

CP. Effect of European Practices on International Power Rectifier Standards.** *L. W. Morton*, General Electric Company

9:30 a.m. Industrial Power Systems

CP. Large Industrial Plant Replaces Electric System.** *E. N. Walton*, Powell River Company, Ltd.

CP. Electrical Innovations in the Alcoa Building.** *L. N. Grier*, Aluminum Company of America

53-72. 240/416-Volt 3-Phase 4-Wire Power and Lighting Supply for Modern Industrial Plants. *William Shuler*, Dayton Power and Light Company

53-73. Electric Distribution and Control for Lighting Systems. *W. H. Kahler*, Westinghouse Electric Corporation; *R. N. Bell*, E. I. du Pont de Nemours and Company, Inc.

9:30 a.m. Relays

53-13. Pilot-Wire Circuits for Protective Relaying—Experience and Practice 1942–1950. *Project Committee on Pilot Wires*

53-21. A Review of Back-up Relaying Practices. *Project Committee on Transmission Line Protection*

53-14. Remote Tripping Schemes. *Project Committee on Remote Tripping Schemes*

53-74. A New Inverse Time Overcurrent Relay With Adjustable Characteristics. *W. K. Sonnemann*, Westinghouse Electric Corporation

53-75. Principles of Induction-Type Relay Design. *W. E. Glassburn, W. K. Sonnemann*, Westinghouse Electric Corporation

9:30 a.m. Conference on Steel and Wood Towers

CP. Experience With Wood Versus Steel Construction on the Public Service Company of Colorado Transmission System.** *L. M. Robertson*, Public Service Company of Colorado

CP. Wood Versus Steel Construction for Transmission Lines.** *K. T. Deutsch*, Denver Federal Center

CP. A Review of the Use of Wood for Transmission-Line Structures.** *R. G. Yerk*, Hughes Brothers, Inc.

CP. Modern 220-Kv Steel-Tower Transmission-Line Construction.** *A. N. Shealy, Edward Fritz*, Pennsylvania Water and Power Company

CP. A Study of Cost of High-Voltage Transmission Lines in Alabama Using Wood and Steel Structures.** *L. B. Murray, C. P. Ussery*, Tennessee Copper Company

CP. Improvements in Performance of Steel and Wood Transmission Lines.** *C. A. Booker*, New England Power Service Company

CP. Wood Versus Steel 110-Kv Transmission Line From the Lightning Flashover Standpoint.** *J. A. Rawls*, Virginia Electric and Power Company

9:30 a.m. Ultrahigh-Frequency Television

CP. General Aspects of Ultrahigh-Frequency Broadcasting.** *E. W. Allen, Jr.*, Federal Communications Commission

CP. Ultrahigh-Frequency Transmitting Equipment.** *Dana Pratt*, RCA Victor Division

CP. New Devices for Broadbanding Ultrahigh-Frequency Television Transmitters.** *F. E. Talmage*, RCA Victor Division

CP. An Experimental Study of Wave Propagation at 850 Megacycles.** *D. W. Peterson, Jess Epstein*, RCA Laboratories

CP. Selection and Amplification of Ultrahigh-Frequency Television Signals.** *J. W. Waring, W. P. Boothroyd*, Philco Corporation

9:30 a.m. Semiconductors

CP. Theory of Photoconductivity.** *H. Y. Fan*, Purdue University

CP. Properties of Photoconductors.** *A. Rose*, RCA Laboratories

CP. Germanium Phototransistors.** *J. N. Shive*, Bell Telephone Laboratories, Inc.

CP. Barrier Layer Phenomena in Titanium Dioxide.** *R. G. Breckenridge, N. Oshinsky*, Bureau of Standards

2:00 p.m. Semiconductors

CP. Zener Breakdown as a Function of Material Resistivity.** *B. Sawyer*, Bell Telephone Laboratories

CP. A Tetrode Transistor.** *I. A. Lesk*, General Electric Company

CP. Theory of Alpha for Fused-Contact Transistors.** *E. L. Steele*, General Electric Company

CP. Radiochemical Studies on Germanium.** *G. H. Morrison*, Sylvania Electric Products, Inc.

2:00 p.m. Land Transportation

53-50. Design Factors Favoring Diesel Locomotive Electrical Maintenance. *J. Stair, Jr.*, Pennsylvania Railroad

53-76. Equipment and Functions of a Modern Diesel Locomotive Heavy Electric Repair Shop. *F. Thomas*, New York Central System

53-77. Diesel-Electric Locomotive Ground Relays. *G. R. McDonald*, General Electric Company

CP. Maintenance of Electric Equipment of Diesel-Electric Locomotives.** *W. H. Eunson, T. L. Weybrew*, Westinghouse Electric Corporation

53-51. A New Control for Heavyweight Rapid-Transit Cars. *I. W. Lichtenfels*, General Electric Company

53-78. An Axle-Driven Alternator-Rectifier System for Caboose Power Supply. *A. H. Hoffer, G. W. Weber*, General Electric Company

2:00 p.m. Transmission and Distribution

53-79–ACO.* Comparative Cost of Distribution Systems With 4.16-Kv or 13.2-Kv Primary Feeders. *H. G. Barnett, D. N. Reps*, Westinghouse Electric Corporation

53-80. New Instrumentation of A-C Network Calculator With Automatic Features. *L. L. Fountain, R. B. Squires, W. A. Hopkins*, Westinghouse Electric Corporation

53-81. Real Power and Imaginary Power in A-C Circuits. *C. F. Estwick*, Electrical Engineer

2:00 p.m. Transient Performance of D-C Machines

53-82. Fault Transients and Frequency Spectra of a D-C Generator. *D. H. Schaefer*, Naval Research Laboratory

53-83. Flashover Torque of a D-C Generator. *O. C. Coho*, General Electric Company

53-84. Transient Analysis of the Metadyne Generator. *M. Riaz*, Massachusetts Institute of Technology

53-85. Transient Performance of D-C Machinery—I. *John Cybulski, E. L. Brancato, J. P. O'Connor*, Naval Research Laboratory

53-86. Flashing of D-C Machines Caused by Short Circuits. *A. T. McClinton, J. P. O'Connor*, Naval Research Laboratory

2:00 p.m. Power Supply for Resistance Welding Machines

Introductory Remarks. E. L. Bailey, Chrysler Corporation

CP. Resistance Welders—Their Ratings and Characteristics of Their Load.** *W. E. Bostwick*, Precision Welder and Machine Company

CP. The Power Company Section of the Report on Power Supply for Resistance Welding Machines.** *H. W. Tietze*, Public Service Electric and Gas Company

CP. Power Supply for Resistance Welders. Section 6—Information for Power Users.** *W. K. Boice*, General Electric Company

CP. Typical Installations.** *C. E. Pflug*, Nash Kelvinator Corporation

53-87. The Electric Arc in Argon and Helium. *T. B. Jones, Merrill Skolnick, W. B. Kouwenhoven*, Johns Hopkins University. Presentation by title only for discussion

2:00 p.m. Metallic Rectifiers

CP. Metallic Rectifier Review.** *I. R. Smith*, Westinghouse Electric Corporation

CP. Problems to Consider in Applying Selenium Rectifiers.** *J. Gramels*, Bell Telephone Laboratories

CP. Metallic Rectifier Ratings.** *C. E. Hamann*, General Electric Company

CP. Methods of Testing Metallic Rectifiers.** *W. F. Bonner*, Federal Telephone and Radio Corporation

CP. Protection of Selenium Rectifiers Against Salt, Moisture, Fungus.** *O. S. Aikman*, Fansteel Metallurgical Corporation

2:00 p.m. Magnetic Materials

CP. Present Status of Magnetic Theory: A Review of the Washington Conference on Magnetism.** *J. E. Goldman*, Carnegie Institute of Technology

CP. The Ferromagnetic Faraday Effect at Microwave Frequencies and Its Application.** *C. L. Hogan*, Bell Telephone Laboratories, Inc.

CP. Improvements in Grain-Oriented Silicon-Iron Alloys.** *G. H. Cole*, Armco Steel Corporation

CP. The Permeability of Silicon-Iron at Very Low Flux Densities.** *E. Both*, Signal Corps Engineering Laboratories

2:00 p.m. Color Television

CP. Present Status of National Television System Committee Color Television.** *D. B. Smith*, Philco Corporation

53-91. Transmitting Terminal Apparatus for National Television System Committee Color Television. *Page Burr*, Hazeltine Electronics Corporation

CP. The Synchronization Problem in Color Television.** *Donald Fink*, Philco Corporation

CP. Network Transmission of Color Television Signals.** *J. G. Reddeck*, RCA Laboratories; *H. C. Gronberg*, National Broadcasting Company

53-90. Democratic and Republican Political Conventions. *R. W. Ralston, B. D. Wickline*, Illinois Bell Telephone Company

2:00 p.m. Management

CP. Development of Executive Abilities.** *R. K. Greenleaf*, American Telephone and Telegraph Company

CP. Management Responsibility for Development of Engineers.** *F. K. McCune*, General Electric Company

2:00 p.m. Sections Committee

2:00 p.m. Nuclear Instrumentation

CP. Electronics in the Atomic Energy Commission Biomedical Program.** *J. C. Bugher*, Division of Biology and Medicine, Atomic Energy Commission

53-31. Nuclear Power Plant Control Considerations. *M. A. Schultz*, Westinghouse Electric Corporation

CP. Equipment Used in the Measurement of Gamma Radiation in Atomic Bomb Tests.** *Dr. L. Costrell*, Nucleonic Instrumentation Section, National Bureau of Standards

CP. A Summary of D-C Amplifiers.** *D. L. Collins*, The Victoreen Instrument Company

CP. A High-Sensitivity Fission Counter.** *W. Baer*, Westinghouse Electric Corporation

Wednesday, January 21

9:30 a.m. Communication Switching Systems

CP. Communication Switching Systems as Complex Automata.** *W. Keister*, Bell Telephone Laboratories, Inc.

CP. The Maze-Solving Mouse.** *C. E. Shannon*, Bell Telephone Laboratories, Inc.

CP. Automatic Error Detecting and Correcting.** *R. W. Hamming*, Bell Telephone Laboratories, Inc.

CP. Mechanized Intelligence in Nation-wide Dial Telephone Switching.** *J. B. Newsom*, Bell Telephone Laboratories, Inc.

9:30 a.m. Transmission and Distribution

53-92. Lightning Problems Solved With the Synchronograph. *E. L. Harder, J. M. Clayton*, Westinghouse Electric Corporation

53-93. Lightning Stroke Protection at High Altitude in Peru. *C. M. Foust*, General Electric Company; *B. C. Maine, C. Lee*, Cerro de Pasco Corporation

53-16. Application and Performance of 13–138-Kv Line Expulsion Arresters. *Working Group on Line Expulsion Arresters*

9:30 a.m. Elevators and Escalators

CP. Vertical Transportation—Architects' Viewpoint.** *G. B. Gusrae*, Voorhees, Walker, Foley and Smith

CP. Operatorless Elevators.** *S. J. Clark*, Otis Elevator Company

CP. The Widening Field of Moving Stairways.** *H. C. Hickock*, Westinghouse Electric Corporation

9:30 a.m. The Safety Aspects of Grounding Versus Insulating

CP. Fundamentals and Principles Involved.** *L. S. Inskip*, Bell Telephone Laboratories, Inc.

CP. Primary and Secondary Distribution.** *T. J. Brosnan*, Niagara Mohawk Power Corporation

CP. Heavy Equipment and Industrial Installations.** *J. Steelman, Jr.*, International Nickel Company, Inc.

CP. Domestic and Portable Appliances.** *A. W. Smoot*, Underwriters' Laboratories, Inc.

9:30 a.m. Hydroelectric Systems

53-8. Combatting Frazil Ice in Hydroelectric Stations. *K. J. Granbois*, Safe Harbor Water Power Corporation

53-95. Automatic and Supervisory Control of the Calgary Power Ltd. Hydroelectric System—Some Design Features. *T. E. Cardell, M. W. Clarke, H. Randle*, Calgary Power Ltd.

53-94. Automatic and Supervisory Control of the Calgary Power Ltd. Hydroelectric System—Operating Experiences. *T. E. Cardell, M. W. Clarke, H. Randle*, Calgary Power Ltd.

53-23-ACO.* Electrical Features of the Owens River Gorge Project. *O. L. Sidenfaden*, Department of Water and Power

9:30 a.m. Synchronous Machinery

53-96. Effects of Negative Sequence Currents on Turbine-Generator Rotors. *E. I. Pollard*, Elliott Company

53-97. Turbine-Generator Rotor Heating During Single-Phase Short Circuits. *M. D. Ross, E. I. King*, Westinghouse Electric Corporation

53-98. Short-Circuit Capabilities of Synchronous Machines for Unbalanced Faults. *P. L. Alger, R. F. Franklin, C. E. Kilbourne, J. B. McClure*, General Electric Company

53-99. Reduction of Noise Produced by Small and Medium 2-Pole Turbine-Generators. *L. P. Shildneck, A. J. Wood*, General Electric Company

CP. Hunting Frequencies of Synchronous Motors.** *L. J. Money*, Los Angeles, Calif.

9:30 a.m. Conference on Basic Concepts

CP. Program of the Basic Concepts Subcommittee.** *V. P. Hessler*, University of Illinois

CP. The Development of Logical Deductive Disciplines in the Physical Sciences.** *Henry Margenau*, Yale University

CP. What Is Voltage?** *J. G. Brainerd*, University of Pennsylvania

CP. Progress in the Standardization of Electric and Magnetic Magnitudes and Units.** *J. J. Smith*, General Electric Company

CP. Rationalization and Its Relation to MKS Units.** *C. C. Chambers*, University of Pennsylvania

9:30 a.m. Feedback Control Systems

53-42. Quick Methods for Evaluating the Closed-Loop Poles of Feedback-Control Systems. *G. A. Biernson*, Massachusetts Institute of Technology

53-100. Correlation Between Frequency and Transient Response of Feedback Control Systems. *Yaohan Chu*, Cambridge, Mass.

53-103. Hydraulic Servos Incorporating a High-Speed Hydraulic-Amplifier Actuated Valve. *R. L. Scrafford*, Cornell Aeronautical Laboratory

53-101. Transient Measurement of Feedback-Control Systems. *F. H. Ferguson, C. H. Looney*, Naval Research Laboratory

53-102. Relative Stability of Closed-Loop Systems. *M. J. Kirby, D. C. Beaumariage*, Sperry Gyroscope Company

9:30 a.m. Insulated Conductors

53-168. The Effect of Loss Factor on the Temperature Rise of Pipe Cable and Buried Cable. *Working Group on the Effect of Loss Factor on the Temperature Rise of Pipe Cable and Buried Cable*

53-169. Cyclical Loading of Buried Cable and Pipe Cable. *G. B. Shanklin, F. H. Buller*, General Electric Company

53-170. Procedures for Calculating the Temperature Rise of Pipe Cable and Buried Cables for Sinusoidal and Rectangular Loss Cycles. *J. H. Neher*, Philadelphia Electric Company

53-171. An Empirical Method for Determining Transient Temperatures of Buried Cable Systems. *Robert Wiseman*, The Okonite Company

2:00 p.m. Electrostatic Hazards in Hospital Operating Rooms

CP. Electrification in Hospital Operating Rooms—Its Generation and Behavior.** *Robin Beach*, Robin Beach Engineers Associated

CP. Electrostatic Problems in Hospital Operating Rooms and Their Resolution.** *C. W. Walter*, Peter Bent Brigham Hospital

CP. Demonstrations Showing How Electrostatic Explosions Occur in Hospital Operating Rooms.** *P. G. Guest*, United States Bureau of Mines

2:00 p.m. Transmission and Distribution

53-104-ACO.* Performance of Electric Joints Utilizing New Silver Coating on Aluminum Conductors. *T. J. Connor, W. R. Wilson*, General Electric Company

53-105-ACO.* An Investigation of the Performance of Power Connectors Used Outdoors With Aluminum Conductors. *H. R. Harrison, R. H. Honebrink*, General Electric Company

53-106. System Stability Limitations and Generator Loading. *H. C. Anderson, H. O. Simmons, Jr., C. A. Woodrow*, General Electric Company

52-260. Economical Utilization of Electric Power Equipment. *Herman Halperin*, Commonwealth Edison Company. Presentation by title only for discussion

2:00 p.m. Relays

53-37. Generator Negative-Sequence Currents for Line-to-Line Faults. *R. F. Lawrence, R. W. Ferguson*, Westinghouse Electric Corporation

CP. Back-up Protection for Generators.** *E. T. B. Gross*, Illinois Institute of Technology; *L. B. LeVisconte*, Sargent and Lundy

53-41. Application of Relays for Unbalanced Faults on Generators. *J. E. Barkle*, Westinghouse Electric Corporation; *Frank von Roeschlaub*, Ebasco Services, Inc.

53-52. Protection of Generators Against Unbalanced Currents. *J. E. Barkle, W. E. Glassburn*, Westinghouse Electric Corporation

CP. A Negative-Phase-Sequence Overcurrent Relay for Generator Protection.** *L. E. Goff, W. C. Morris*, General Electric Company

2:00 p.m. Electrostatic Processes and Power Generation

53-27-ACO.* Air Pollution Prevention in Electric Generating Stations. *H. A. Bauman*, Consolidated Edison Company of New York, Inc.

53-32. Electrostatic Precipitators for Electric Generating Stations. *H. J. White*, Research Corporation

CP. The Application of Selenium Rectifiers to Power Supplies for Electric Precipitation.** *R. G. Schlawin, P. V. Hahn*, General Electric Company

CP. Some Experiments on the Mechanism of Wire Vibration.** *G. W. Penney*, Carnegie Institute of Technology

2:00 p.m. Fundamental Evaluation of Insulation

53-11. Studies of Impulse Strength and Impulse Testing Problems in High-Voltage Generators. *G. L. Moses, R. J. Alke*, Westinghouse Electric Corporation. Presentation by title only for discussion

53-3. Testing Electrical Insulation of Rotating Machinery With High-Voltage Direct Current. *G. L. Hill*, Pacific Gas and Electric Company. Presentation by title only for discussion

CP. Test Code for Evaluation of Systems of Insulating Materials for Random-Wound Electric Machinery.** *Subcommittee Report by P. L. Alger*

CP. A Method of Evaluating Insulation Systems in Motors.** *C. B. Leape, J. McDonald, G. P. Gibson*, Westinghouse Electric Corporation

CP. Motor Insulation Life as Measured by Accelerated Tests and Dielectric Fatigue.** *C. J. Herman*, General Electric Company

CP. Progress Report on Functional Evaluation of Motor Insulation Systems.** *R. Harrington*, General Electric Company

CP. Leakage-Voltage Characteristics of Insulation Related to D-C Dielectric Strength.** *J. S. Johnson, J. W. Clokey*, Westinghouse Electric Corporation

2:00 p.m. Electrical Properties of Gases

CP. Detection of Nuclear Radiation.** *H. Kallman*, New York University

CP. Ionization Chambers.** *H. W. Fulbright*, University of Rochester

CP. Proportional Counters.** *J. B. H. Kuper*, Brookhaven National Laboratory

CP. Geiger Counters.** *S. A. Korff*, New York University

2:00 p.m. Instruments and Measurements

53-10-ACO.* Watt-hour Meter Reading and Billing. *J. R. Macintyre*, General Electric Company; *W. C. Israel*, Detroit Edison Company

53-22. Accurate Radio-Frequency Microvoltages. *M. C. Selby*, National Bureau of Standards

CP. Multirange Audio-Frequency Thermocouple Instruments of High Accuracy.** *F. L. Hermach*, National Bureau of Standards

CP. The C-1 Alarm and Control System for Use With Microwave Radio Relay.** *Harold M. Pruden*

CP. A Special-Purpose Digital Telemetering System.** *C. A. Piper*

53-1. Sensitivity and Output Formulas for the Resistance Bridge. *P. M. Andress*, Rubicon Company. Presentation by title only for discussion

2:00 p.m. Feedback Control Systems

53-107. A Differential Analyzer Study of Certain Nonlinearly Damped Servomechanisms. *R. R. Caldwell, V. C. Rideout*, University of Wisconsin

53-108. Coulomb Friction in Feedback-Control Systems. *V. B. Haas, Jr.*, University of Connecticut

53-109. Limiting in Feedback-Control Systems. *R. J. Kochenburger*, University of Connecticut

53-110. Some Saturation Phenomena in Servomechanisms With Emphasis on the Tachometer Stabilized System. *Emanuel Levinson*, Sperry Gyroscope Company

53-17. Drag-Cup A-C Tachometer With Constant-Current Excitation. *R. H. Frazier*, Massachusetts Institute of Technology. Presentation by title only for discussion

2:00 p.m. Communication Switching Systems

53-111. Automatic Call Recording and Accounting in the SATT System. *J. E. Ostline*, Automatic Electric Company

53-112. A Subscriber Toll Dialing Tape Reader. *W. H. Blashfield*, North Electric Manufacturing Company

53-113. Principles of Tape-to-Card Conversion in the AMA System. *W. B. Groth*, Bell Telephone Laboratories, Inc.

53-114. Mechanized Billing of AMA Toll Messages. *F. D. Slade*, American Telephone and Telegraph Company

2:00 p.m. Petroleum Industry

CP. Power Generation and Distribution in Petroleum Refineries.** *R. L. Lawrence, H. B. Thacker*, Westinghouse Electric Corporation

CP. Use of Outdoor Switchgear in Petroleum Refineries.** *E. R. Hoyle*, Sinclair Refining Company

CP. Report on the Activities of the Electric Equipment Subcommittee of the American Petroleum Institute—Refining Division.** *L. M. Goldsmith*, Atlantic Refining Company

Thursday, January 22

9:30 a.m. Radio Communications Systems

CP. Communications for Civil Defense.** *C. A. Armstrong*, American Telephone and Telegraph Company

CP. Conelrad.** *R. J. Rention*, Federal Communications Commission

CP. The New Jersey Turnpike—A Unique Highway Communication System.** *J. R. Neubauer*, RCA Victor

CP. Path Testing for Microwave Radio Routes.** *R. D. Campbell*, American Telephone and Telegraph Company

9:30 a.m. Magnetic Amplifiers

53-117. Dynamic Hysteresis Loops of Several Core Materials Employed in Magnetic Amplifiers. *H. W. Lord*, General Electric Company. Presentation by title only for discussion

CP. Improved Techniques in Analyzing the Transient Response of Magnetic Amplifiers.** *W. A. Geyger*, Naval Ordnance Laboratory

53-18. An Instability of Self-Saturating Magnetic Amplifiers Using Rectangular Loop Core Materials. *S. B. Batdorf, W. N. Johnson*, Westinghouse Research Laboratories

CP. An Application of Magnetic Amplifier Circuits to Perform Multiplication.** *L. A. Finzi, R. A. Mathias*, Carnegie Institute of Technology

53-20. Saturable Reactors With Inductive D-C Load. Part II, Transient Response. *H. F. Storm*, General Electric Company

9:30 a.m. Protective Devices

53-118. Lightning Investigations at Two Major 115/230-Kv Stations, 1947–1951. *H. M. Ellis*, Hydro-Electric Power Commission of Ontario

53-119. Performance Characteristics of Lightning Protective Devices. *Lightning Protective Devices Subcommittee*

53-15. Guide for Application of Ground-Fault Neutralizers. *Working Group on Fault Limiting Devices.* Presentation by title only for discussion

53-120. Application Guide for the Grounding of Synchronous Generator Systems. *Fault Limiting Devices Subcommittee*

9:30 a.m. Transformers

53-38. Aging Evaluation of Dry-Type Transformer Insulating Systems. *H. C. Stewart, L. C. Whitman, A. L. Scheideler*, General Electric Company

53-121. Transformer Cooling Equipment Has Optimum Operating Conditions. *H. A. Fohrhaltz*, General Electric Company

53-122. Short-Time Thermal and Mechanical Limits for Transformers and Reactors. *J. E. Clem*, Consulting Engineer

53-123. A Solution of a Common Insulation Problem. *G. I. Cohn*, Illinois Institute of Technology; *F. J. Vogel*, Allis-Chalmers Manufacturing Company

CP. Analysis of the Delta Grounded Transformer.** *E. T. B. Gross, K. J. Rao*, Illinois Institute of Technology

53-39-ACO.* A New Liquid-Filled Current Transformer With Novel Features. *L. W. Marks*, General Electric Company

52-190. 1,100,000-Kva Short-Circuit Transformer in the New High-Capacity Switchgear Testing Laboratory. *B. A. Cogbill*, General Electric Company. Presentation by title only for discussion

9:30 a.m. Power Generation and Induction Machinery

53-30. Underexcited Operation of Large Turbine-Generators on Pacific Gas and Electric Company's System. *V. F. Estcourt*, Pacific Gas and Electric Company; *C. H. Holley*, General Electric Company; *W. R. Johnson*, Pacific Gas and Electric Company; *P. H. Light*, General Electric Company

53-124. Axial Magnetic Forces on Induction-Machine Rotors. *C. E. Bradford, R. G. Rhudy*, General Electric Company

CP. The Use of Motors Outdoors.** *R. B. Schultz*, Elliott Company

CP. Effect of Purchasers' Specifications and Industry Standards on Induction-Motor Design.** *W. M. Schweder*, General Electric Company

9:30 a.m. Dielectrics

CP. Intrinsic Electric Breakdown in Liquid Dielectrics.** *A. H. Sharbaugh*, General Electric Company

CP. Impulse Ionization and Breakdown in Liquid Dielectrics.** *C. J. Bute, E. L. C. Larson, G. M. L. Sommerman*, Northwestern University

CP. Effect of Corona Discharges on Electric Breakdown of Solid Insulation.** *T. W. Dakin, H. M. Philofsky*, Westinghouse Electric Corporation

CP. Dielectric Breakdown of Sulfur Hexafluoride in Nonuniform Fields.** *C. N. Works, T. W. Dakin*, Westinghouse Electric Corporation

53-125. Nondestructive Testing of Insulation. *E. L. Brancato*, Naval Research Laboratory

53-126. Fluorine Containing Gaseous Dielectrics. *G. Camilli, R. E. Plump*, General Electric Company

53-6. Polyethylene Terephthalate—Its Uses as a Capacitor Dielectric. *M. C. Wooley, G. T. Kohman, W. McMahon*, Bell Telephone Laboratories, Inc. Presentation by title only for discussion

9:30 a.m. Instruments and Measurements in Medicine and Biology

CP. A Liquid Level Indicator for Condensed Gases at Low Temperatures.** *W. E. Williams, E. Maxwell*

CP. Electronic Voltage Regulators as Used in X-Ray Equipment.** *James Ball*, Picker X-Ray Corporation

53-127. Wheatstone Bridge for Admittance Determinations of Highly Conducting Materials at Low Frequencies. *H. P. Schwan*, University of Pennsylvania; *Karl Sittel*, Franklin Institute.

53-128. Cathode-Ray Synchroscope and Automatic Synchroniser. *Dr. M. Abdel-Halim Ahmed*, Fouad I University; presented by *E. P. Felch*, Bell Telephone Laboratories, Inc.

CP. Recent Developments in Potentiometer Pressure Pickups.** *V. C. Westcott*

9:30 a.m. Noncalculative Applications of Computers

CP. Use of Computers for Process Control.** *Eugene Ayres*, Gulf Research and Development Company

CP. An Automatic Inventory System for Air Travel Reservation.** *M. L. Haselton, E. L. Schmidt*, Teleregister Corporation

CP. Program Control of Predictable Industrial Processes.** *William Pease*, Massachusetts Institute of Technology

CP. Use of Computers for Library Searching.** *J. W. Perry*, Massachusetts Institute of Technology

53-4. Adjustable-Speed Drives for Deep Draw Presses. *C. E. Robinson, A. P. DiVincenzo*, Reliance Electric and Engineering Company. Presentation by title only for discussion

9:30 a.m. Industrial Control

CP. Methods of Rating High-Interrupting-Capacity Controllers.** *J. D. Leitch*, Electric Controller and Manufacturing Company

CP. Motor Control Centers and Their Co-ordination With Power Distribution Systems.** *R. E. Gasparoli*, General Electric Company

CP. Overload Protection of Adjustable-Voltage Drives.** *W. Schaelchlin*, Westinghouse Electric Corporation

53-129. The Application and Standardization of High-Rupturing-Capacity Current-Limiting Fuses. *J. W. Gibson*, General Electric Company. Presentation by title only for discussion

53-19. Arcing Time of High-Voltage Air-Break Contactors at Low Currents. *C. A. Lister*, Electric Controller and Manufacturing Company. Presentation by title only for discussion

9:30 a.m. Gas Tubes

CP. On the Design and Measurement of Hydrogen Thyratron Modulator Characteristics.** *S. Goldberg, K. J. Germeshausen*, Edgerton, Germeshausen, and Greer, Inc.

CP. Some Factors Involved in Breakdown, Conduction, and Recovery of the Hydrogen Thyratron.** *W. T. Allis*, Massachusetts Institute of Technology; *S. T. Martin*, Consulting Engineer; *K. J. Germeshausen*, Edgerton, Germeshausen, and Greer, Inc.

CP. Fast-Response High-Current Thyratron Power Supplies for Inductive Loads.** *J. H. Burnett*, Electrons, Inc.

CP. Experimental Studies and Applications of Explosive Pressures Produced by Sparks in Confined Channels.** *H. C. Early, W. G. Dow*, University of Michigan

2:00 p.m. Magnetic Amplifiers

53-130. Dielectric Amplifiers, Part I. *G. W. Penney, J. R. Horsch, E. A. Sack*, Carnegie Institute of Technology

Conference papers on "Nonlinear Circuit Theory"

2:00 p.m. Switchgear

53-131. A Fundamental Factor Controlling the Unit Dielectric Strength of Oil. *W. R. Wilson*, General Electric Company

53-56. Stability of DBPC Inhibited Oil in Oil Circuit Recloser Operation. *Kazumi Oura, R. N. Hazelwood, R. M. Frey*, Line Material Company

53-43. An Investigation of the Arc-Quenching Behavior of Sulfur Hexafluoride. *H. J. Lingal, A. P. Strom, T. E. Browne, Jr.*, Westinghouse Electric Corporation

53-46. A New High-Voltage Outdoor Load Interrupter Switch. *H. J. Lingal, J. B. Owens*, Westinghouse Electric Corporation

CP. A New Coaxial Blade Transfer Switch.** *S. C. Killian, N. Polgov*, Delta-Star Electric Company

CP. Report of National Electrical Manufacturers Association Activity on Bushing Standardization.** *M. H. Hobbs*, Westinghouse Electric Corporation

2:00 p.m. Transformers

CP. Transformer Models for Determination of Transient Voltages.** *P. A. Abetti*, General Electric Company

53-2. A New Method of Obtaining Insulation Co-ordination of Transformers. *W. C. Sealey, F. J. Vogel,* Allis-Chalmers Manufacturing Company

53-133. Natural Frequencies of Coils and Windings Determined by Equivalent Circuits. *P. A. Abetti, F. J. Maginniss,* General Electric Company

53-134. A Sudden Gas Pressure Relay for Transformer Protection. *R. L. Bean, H. L. Cole,* Westinghouse Electric Corporation

CP. Bushing Standardization.** *National Electrical Manufacturers Association Joint Committee*

2:00 p.m. Power Generation and Induction Machinery

53-25. A New Regulator and Excitation System. *J. T. Carleton, P. O. Bobo, W. F. Horton,* Westinghouse Electric Corporation

CP. Economics of Boiler Feed Pump Drives.** *R. W. Ferguson, E. W. DuBois,* Westinghouse Electric Corporation

CP. Matching Motor Characteristics to the Characteristics of the Driven Auxiliary Equipment.** *E. E. Edgell, W. H. Nichols,* Westinghouse Electric Corporation

CP. Effect of Load-Estimating Errors on Reserve Capacity as Determined by the Probability Method.** *G. Calabrese,* New York University

2:00 p.m. Dielectrics

CP. New High-Temperature Silicone Resins.** *J. F. Dexter,* Dow Corning Corporation

CP. Tailoring of Silicone Rubber to Meet Electrical Requirements.** *M. G. Noble, D. A. Lupfer,* General Electric Company

CP. Applications of Teflon in the Electrical Industry.** *B. E. Ely,* E. I. du Pont de Nemours and Company

CP. The Electrical Decomposition of Sulfur Hexafluoride.** *D. Edelson, C. A. Beiling, G. T. Kohman,* Bell Telephone Laboratories, Inc.

CP. The Corona Decomposition of Fluorocarbon Gases.** *N. M. Bashara, J. D. LaZerte,* Minnesota Mining and Manufacturing Company

53-135. Some Fluorinated Liquid Dielectrics. *N. M. Bashara,* Minnesota Mining and Manufacturing Company. Presentation by title only for discussion

2:00 p.m. Electrical Techniques in Medicine and Biology

CP. A High-Pressure Ionization Chamber.** *P. A. Duffy, J. Borzin,* Westinghouse Electric Corporation

CP. A Simple Gamma Radiation Monitor for Visual Warning or Telemetering.** *M. E. Hayes, Zane Collins,* Westinghouse Electric Corporation

CP. The Localization and Mapping of Gamma-Ray Sources With Collimated Scintillation Counters.** *Benedict Cassen, R. L. Libby, F. K. Bauer,* Wadsworth General Medical and Surgical Hospital

53-136. The Elements of Electrocardiographic Theory. *Ernest Frank,* Moore School of Electrical Engineering. Presentation by title only for discussion

53-137. Application of Electrical and Acoustic Impedance Measuring Techniques to Problems in Diathermy. *H. P. Schwan, E. L. Carstensen,* Moore School of Electrical Engineering. Presentation by title only for discussion

2:00 p.m. Industrial Control

CP. Construction, Components, and Control of Packaged Adjustable-Voltage Drives.** *Gerald Secor,* Cutler-Hammer, Inc.

CP. Electronic Packaged Drives.** *E. F. Kubler,* General Electric Company

CP. Packaged-Drive Design Problems.** *E. H. Vedder,* Westinghouse Electric Corporation

CP. Packaged Adjustable-Voltage Drives.** *S. P. Finnegen, W. H. Turner, Jr., L. Wolfson,* General Electric Company

2:00 p.m. Wire Communications Systems

CP. L3 Coaxial System—System Design.** *C. H. Elmendorf, A. J. Grossman, R. D. Ehrbar.* Bell Telephone Laboratories, Inc.

CP. L3 Coaxial System—Amplifiers.** *L. H. Morris, G. H. Lovell, F. R. Dickinson,* Bell Telephone Laboratories, Inc.

CP. L3 Coaxial System—Equalization and Regulation.** *R. W. Ketchledge, T. R. Finch,* Bell Telephone Laboratories, Inc.

CP. L3 Coaxial System—Television Terminals.** *J. W. Rieke, R. S. Graham,* Bell Telephone Laboratories, Inc.

2:00 p.m. High-Vacuum Tubes

CP. 1-Kw Transmitting Tetrode for Ultrahigh Frequency.** *W. P. Bennett, H. F. Kazanowski.* Radio Corporation of America

CP. A New 10-Kw Air-Cooled Tetrode for Very-High-Frequency Television Service.** *M. B. Shrader,* Radio Corporation of America

CP. Cathode-Ray Target Tube for Pulse Height Analysis.** *John Hartman,* Allen B. Du Mont Laboratories, Inc.

CP. Discussion of Electromagnetic and Electrostatic Focus for Picture Tubes.** *W. A. Dickinson,* Sylvania Electric Products Inc.

53-173. High-Power Industrial Vacuum Tubes Having Thoriated-Tungsten Filaments. *R. B. Ayer,* Radio Corporation of America. Presentation by title only for discussion

53-174. The Nickel Base Indirectly Heated Oxide Cathode. *A. M. Bounds, P. N. Hambleton,* Superior Tube Company. Presentation by title only for discussion

2:00 p.m. Computing Devices

Friday, January 23

9:30 a.m. Power Generation and System Engineering

53-34. Historical Approach to Speed and Tie-Line Control. *Robert Brandt,* New England Power Company

CP. Load Controlling System for Large and Quick Load Changes.** *A. F. Schwendner,* Westinghouse Electric Corporation

53-55. Prime Mover Speed Governors and the Interconnected System. *P. G. Ipsen, J. R. Norton,* General Electric Company

53-139-ACO.* Controllability of High-Pressure-High-Temperature Reheat Steam Plants. *P. S. Dickey,* Bailey Meter Company

53-140-ACO.* Boiler Designs Developed for Controllability. *P. R. Loughin,* Babcock and Wilcox Company

9:30 a.m. Switchgear

53-44. Operating Mechanisms for High-Capacity High-Voltage Oil Circuit Breakers. *E. B. Rietz,* General Electric Company

53-58. A 161-Kv 10,000-Megavolt-Ampere Steel-Clad Impulse Circuit Breaker—The First of a Line of High-Capacity High-Voltage Circuit Breakers. *C. J. Balentine, C. M. Ratliff, Jr., G. C. McBride,* General Electric Company

53-57. Improved Outdoor Oil Circuit Breakers for Medium Voltages. *R. B. Shores, E. J. Olsen,* General Electric Company

CP. Is the European Circuit Breaker Rating System Really More Conservative than the American?** *R. C. Van Sickle,* Westinghouse Electric Corporation

CP. Considerations in the Operation of Outdoor Switching Equipment Under Low Ambient Temperature Conditions.** *A. H. Powell, E. B. Rietz,* General Electric Company.

9:30 a.m. Rotating Machinery

53-141. Design of Single-Phase Motors to Minimize Voltage Dips. *J. E. Williams,* University of Illinois

CP. Analysis of Induction Tachometer Generators.** *Kurt Burian,* General Motors Laboratories, Inc.

53-5. The Polyphase Induction Machine With Solid Rotor. *H. M. McConnell,* Carnegie Institute of Technology

53-12. Determination of Network Constants of Polyphase Induction Motors. *N. F. Tsang,* Tulane University; *T. C. Tsao,* Consolidated Edison Company of New York, Inc.

53-142. Investigation of Magnetic Mixtures for Clutch Application. *W. P. Jones,* Naval Research Laboratory

53-176. Bibliography of Electric Couplings. *Subcommittee on Electric Couplings.* Presentation by title only for discussion

9:30 a.m. Electrets

CP. Electrets.** *G. G. Wiseman,* University of Kansas; *E. G. Linden,* Fort Monmouth, N. J.

CP. Plastic Electrets.** *H. H. Wieder,* National Bureau of Standards

CP. The Nature of Phenomena in Electrets.** *W. F. G. Swann,* Bartol Research Foundation

9:30 a.m. Digital Computers

CP. Operating Experience With a Digital Computer.** *G. W. Hobbs,* General Electric Company

CP. Operating Efficiencies of ENIAC, ORDVAC, and EDVAC.** *Homer Spence,* Aberdeen Proving Ground

CP. Nondestructive Sensing of Magnetic Cores.** *D. A. Buck, W. I. Frank,* Massachusetts Institute of Technology

CP. Checking Codes for Digital Computers.** *J. M. Diamond,* Philadelphia, Pa.

53-7. Digital-to-Analogue Shaft-Position Transducers. *S. J. O'Neil,* Air Defense Office. Presentation by title only for discussion

9:30 a.m. Complexity of Electronic Systems

CP. This Problem in the Signal Coaps.** *E. L. Nelson,* Signal Corps Engineering Laboratory

CP. Are Our Military Electronic Systems Too Complex?** *J. M. Bridges,* Bureau of Ordnance

CP. Some Viewpoints of the Air Forces.** Presented by representatives from the Wright Air Development Center

CP. Complexity Versus Reliability in Military Electronic Systems.** *T. I. Paganelli,* General Electric Company

CP. A Manufacturer's Viewpoint.** *H. T. Budenbom,* Bell Telephone Laboratories, Inc.

9:30 a.m. Special Communication Applications

CP. Audio-Frequency Filters on Negative Feedback Principle.** *Tadeusz Janisz,* University of Detroit

53-143. Maximum Impedance Transformations in Band-Pass Filters. *T. J. O'Donnell,* Gulf Research and Development Company; *E. M. Williams,* Carnegie Institute of Technology

53-144-ACO.* Narrow-Band Speech Spectrum in Relation to Reduced Channel Crowding. *J. P. Neil,* Palo Alto, Calif.

9:30 a.m. General Industry Applications

CP. Operating Characteristics of Driving Elements in Regulated Systems.** *W. O. Osbon,* Westinghouse Electric Corporation

53-145. Application and Operation of D-C Drives on Rubber Calenders. *J. F. Sellers,* Allis-Chalmers Manufacturing Company; *B. G. Wheeler,* Cutler-Hammer, Inc.; *A. C. Halter,* Allis-Chalmers Manufacturing Company

53-146-ACO.* A Study of the Dual-Motor Tandem Conveyor Belt Drive. *G. H. Mather, R. K. Albright,* Link-Belt Company

9:30 a.m. Production and Application of Light

CP. Ultraviolet Radiation for Air Sanitation and Product Protection.** *A. J. Dusault,* Westinghouse Electric Corporation

CP. Photochemical Sources and Applications of Ultraviolet.** *L. J. Buttolph,* General Electric Company

CP. Industrial Applications of Infrared.** *I. J. Barber,* Fostoria Pressed Steel Corporation

9:30 a.m. Cathodic Protection

2:00 p.m. Power Generation and System Engineering

53-49. Principles of Load Allocation Among Generating Units. *E. E. George*, Ebasco Services, Inc.

53-147. Techniques in Handling Load Regulating Problems on Interconnected Power Systems. *C. Nichols*, Leeds and Northrup Company

53-40—ACO.* A Simplified System of Centralized Load-Frequency Control. *J. J. Larew, G. S. Lunge, E. E. Lynch*, General Electric Company

53-172. Tie-Line Power and Frequency Control of Electric Power Systems. *C. Concordia, L. K. Kirchmayer*, General Electric Company

53-148—ACO.* Effect of Swinging Loads on Steam-Plant Economy. *W. D. Wilder, H. J. Thielke*, United States Department of Interior

2:00 p.m. Switchgear

53-149—ACO.* New Line of Low-Voltage Air Circuit Breakers. *B. S. Beall, III, V. N. Stewart*, General Electric Company

53-150—ACO.* A New Design of Low-Voltage Drawout Switchgear. *F. W. Lewis*, General Electric Company

53-45. Switching Equipment for New Switchgear Development Laboratory. *E. J. Casey*, General Electric Company

53-47. Effect of Voltage Recovery Rates on Interrupting Performance of Air-Blast Circuit Breakers. *E. B. Rietz, J. W. Beatty*, General Electric Company

CP. System Recovery Voltage and Short-Circuit Duty for High-Voltage Circuit Breakers.** *I. B. Johnson, A. J. Schultz, W. F. Skeats*, General Electric Company

2:00 p.m. Permanent-Magnet Generators and Motors

53-151. Design Considerations of Fractional-Horsepower-Size Permanent-Magnet Motors and Generators. *D. D. Hershberger*, General Electric Company

53-152. New Method for the Optimum Design of Permanent Magnets Subjected to Demagnetizing Effects. *H. K. Ziegler*, Elberon, N. J.

53-153. Evolution of Permanent-Magnet Fractional-Horsepower-Size Motors and Generators. *W. R. Goss*, General Electric Company

53-9. Design Calculations for Permanent-Magnet Generators. *David Ginsberg, L. J. Misenheimer*, Engineer Research and Development Laboratories

2:00 p.m. Basic Sciences

CP. Equations for Determining Current Distribution Among the Conductors of Busses Comprised of Double-Channel Conductors.** *C. M. Siegel*, 11-R Copeley Hill Project; *T. J. Higgins*, University of Wisconsin

53-154. The Influence of a Transverse Magnetic Field on an Unconfined Glow Discharge. *W. D. McBee*, Sperry Gyroscope Company; *W. G. Dow*, University of Michigan. Presentation by title only for discussion

A New Method for Treating Electron Tubes When Used as Superregenerative Detectors. *Abd El-Samie Mostafa*, Farouk I University; *M. El-Shishini Bey*, member of Egyptian Senate. Presentation by title only for discussion

- **53-158. Part I. Superregenerative Circuits Under No Signal Condition**
- **53-157. Part II. Superregenerative Circuits Under Signal Condition**
- **53-155. Part III. Experimental Investigation of Superregenerative Circuits**

53-156. Oscillatory Circuits Containing Iron Cored Inductances With a Generalised Analysis of Performance and Design of Static Stabilizers Using Such Circuits. *Abd El-Samie Mostafa*, Farouk I University; *M. El-Shishini Bey*, member of Egyptian Senate. Presentation by title only for discussion

53-159. Effects of Harmonics on the Frequency of Oscillation as Well as on the Asymmetry of the Resonance Curves. *Abd El-Samie Mostafa*, Farouk I University. Presentation by title only for discussion

2:00 p.m. Analogue Computer Developments

53-160. A New-Design 60-Cycle A-C Network Analyzer. *J. L. Davidson*, Long Island Lighting Company; *R. E. Koll*, System Analyzer Corporation

CP. New Electric Analogue Computers for the Aircraft Industry.** *H. E. Criner, B. N. Locanthi*, Computer Engineering Associates

CP. Microsyn Electromagnetic Components.** *R. K. Mueller*, Massachusetts Institute of Technology

CP. Precision High-Current Computer Power Supplies.** *Allen Rosenstein*, University of California

2:00 p.m. Telegraph Systems

53-163. A Nonarmored Submarine Telegraph Cable. *C. S. Lawton*, Western Union Telegraph Company; *L. H. Hutchins, Jr.*, Simplex Wire and Cable Company

53-164. Wire and Cable in the Telegraph Industry. *W. F. Markley*, Western Union Telegraph Company

CP. A Switching System for Dispatcher Test Wires.** *P. R. Easterlin*, Western Union Telegraph

2:00 p.m. Light Sources and Control Devices

CP. Filament Sources.** *Kirk Reid*, General Electric Company

CP. Mercury and Vapor Sources.** *Eugene Beggs*, Westinghouse Electric Corporation

CP. Fluorescent Sources.** *Theodore Sargent*, Sylvania Electric Products, Inc.

CP. Ballasts and Circuit Control Devices.** *W. C. Anderson*, Jefferson Electric Company

2:00 p.m. Electrochemical Processes

CP. History and Development of the Magnesium Industry.** *T. M. Baxandall*, Dow Chemical Company

CP. History and Development of Major Electrolytic Processes.** *W. E. Gutzwiller*, Allis-Chalmers Manufacturing Company

CP. Economics of Insurance of Generating and Converting Equipment for Chemical Process.** *J. N. Fogg*, Ethyl Corporation

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(Continued from page 77)

basic switching plan of the Number 5 Crossbar Switching System, and the recording aspects of Automatic Message Accounting. Actual switching systems equipment will be observed and demonstrated. Included in the tour will be the Automatic Message Accounting System Laboratory, the Nationwide Dialing System Laboratory, and the Number 5 Crossbar Central Office Laboratory. The Automatic Message Accounting demonstration will include the equipment used to record the data required for billing, the Ring Translator, which furnishes the number of the calling telephone, and the accounting center where the recorded data are processed through a series of automatic machines. How long-distance calls are automatically established by the latest toll crossbar switching system will be shown, highlighting the basic intelligence unit of this switching system, which is called the Card Translator, and illustrating the use of multifrequency pulsing. A demonstration of the method of operation of the latest automatic switching system for local telephone calls will be given also.

ETA KAPPA NU AWARD DINNER

The Annual Recognition Dinner of the Eta Kappa Nu Association for the most outstanding young electrical engineer for 1952 will be held on Monday evening, January 19, 1953. The Eta Kappa Nu plaque designating this engineer will be awarded to Dr. J. V. N. Granger of the Stanford Research Institute, Stanford, Calif. In addition, Gustave W. Staats of the Allis-Chalmers Manufacturing Company of Milwaukee, Wis., and Edward O. Johnson of the RCA Laboratories at Princeton, N. J., will receive honorable mention citations. The award and honorable mention citations are earned by outstanding electrical achievement in conjunction with services rendered to the community and fellowmen and by cultural attainments.

A jury of award comprised of men who have earned distinction in the field of electrical engineering selects the winners. The jury for 1952 consisted of T. G. LeClair (Chairman), E. A. Walker, C. B. Jolliffe, T. C. Fry (for M. J. Kelly), Robin Beach, and E. B. Kurtz, National President, Eta Kappa Nu Association. Elies Elvove, McConnaughy and Elvove, was chairman of the Eta Kappa Nu Award Organization Committee.

SMOKER

The Smoker Committee, under the chairmanship of C. F. Bolles, announces that the smoker will be held at the Hotel Commodore on Tuesday evening, January 20. Most tables seat ten persons and the price of tickets, including gratuities, will be $10 per person. Requests for reservations should be sent to the Smoker Committee at AIEE Headquarters accompanied by remittances made payable to "Special Account, Secretary, AIEE." Such requests must be received not later than January 6.

DINNER-DANCE

The dinner-dance will be held Thursday night, January 22, in the Ballroom of the Hotel Statler. Music will be by Charles Peterson. Tables for ten may be reserved in advance for parties large enough to fill them, and the Dinner-Dance Committee will arrange to combine smaller groups and individuals before the party begins. Members reserving tickets are urged to let the committee know if they wish to be seated with others who are making separate reservations.

The cost of the tickets includes tips and is $12.00 per person. Dress will be formal. Write or call Dinner-Dance Committee at AIEE Headquarters. Make checks payable to "Special Account, Secretary, AIEE."

LADIES' ENTERTAINMENT

The Ladies Committee under the chairmanship of Mrs. E. S. Banghart has arranged a program which should prove both interesting and enjoyable. Registration will begin Sunday afternoon at Ladies' Headquarters, Conference Room 2, Statler Hotel. Monday, January 19, at 4 p.m., there will be the Get-Acquainted Tea. A 9 a.m. breakfast at B. Altman, for which there will be a nominal charge, starts Tuesday's events. At 2:30 p.m. a sight-seeing trip is scheduled through downtown section of New York, for which there will be a charge. At 7 p.m., there will be cocktails, dinner, entertainment, and door prizes in the Penn Top, Hotel

Statler. The charge for the dinner will be $5.00, and requests for reservations should be sent, as soon as possible, to the Ladies Committee at AIEE Headquarters. On Wednesday a trip to the United Nations has been scheduled, for which there will be a 75 cents admission fee plus bus transportation. After the tour, the ladies will be transported by bus to the Tavern-on-the-Green in Central Park for luncheon. Thursday's events start at 12:30 with a fashion show and luncheon (and door prize) for out-of-town ladies in the Sert Room of the Waldorf-Astoria followed by the dinner-dance at 7 p.m. in the Statler Ballroom. Broadcast and theater tickets for the entire week will be available. Coffee will be served each morning.

THEATER TICKETS

As in the past, tickets to the following shows currently playing in New York will be available to all out-of-town AIEE members during the week of the meeting.

	Wednesday Matinee	Evenings
An Evening with Beatrice Lillie (comedy-satire) with Reginald Gardiner	$5.40	$7.20
Bernardine Mary Chase's new comedy	4.80	6.00
Dial M for Murder (drama) with Maurice Evans	4.80	6.00
Guys and Dolls (musical)	4.80	7.80
My Darlin' Aida (musical) with Dorothy Sarnoff, Elaine Malbin	5.40	7.80
New Faces of 1952 (musical)	4.80	7.20
Pal Joey (musical)	4.80	7.80
South Pacific (musical)	4.80	7.20
The Deep Blue Sea (new drama) with Margaret Sullavan	4.80	6.00
The Fourposter (comedy) with Betty Field and Burgess Meredith	4.80	6.00
The King and I (musical)	5.40	8.40
The Male Animal (comedy) with Elliott Nugent, Martha Scott, Robert Preston	4.80	6.00
The Moon Is Blue (comedy) with Donald Cook, Barry Nelson, Janet Riley	4.80*	6.00
The Seven Year Itch (comedy) with Tom Ewell and Vanessa Brown	4.80	6.00
The Time of the Cuckoo (comedy) with Shirley Booth	4.80	8.20
Time Out for Ginger (new comedy) with Melvyn Douglas	4.80	6.00
Two's Company (musical review) with Bette Davis	5.40	7.20
Wish You Were Here (musical)	5.40	8.40
Whistler's Grandmother (new comedy) with Josephine Hull	4.80	6.00
Cinerama (new movie technique)	3.60	4.00

* Thursday matinee.

All prices shown are brokers' prices for orchestra seats which are always $1.20 above box office prices. Whenever possible, tickets will be obtained at box office prices. The earlier requests will obviously have the best chance of avoiding the brokers' fees on the tickets.

Checks should be made payable to: "Theater Ticket Committee, AIEE." Requests also should include first and second choice of both name and date of show, and should be sent to: Theater Ticket Committee, AIEE, ℅ Westinghouse Electric Corporation, Room 2502, 40 Wall Street, New York 5, N. Y.

Preference will be given in order of receipt to requests for seats in blocks of pairs and the committee reserves the right to reduce requests to sell-out shows to two tickets.

All ticket requests will be acknowledged promptly and, at the same time, refund will be made of any money due in excess of the price of tickets purchased.

Please do not include with theater ticket applications payment for any meeting fee or other item for which remittance should be made directly to Institute headquarters.

1953 WINTER GENERAL MEETING COMMITTEE

Members of the 1953 Winter General Meeting Committee are: C. T. Hatcher, Chairman; A. J. Cooper, Vice-Chairman; J. J. Anderson, Secretary; W. J. Barrett, Budget Co-ordinator; M. D. Hooven, Vice-President, District 3; L. F. Hickernell, Chairman, Committee on Technical Operations; G. T. Minasian, Publicity; J. A. Parrott, General Session; J. G. Derse, Dinner-Dance; D. E. Sullivan, Inspection Trips; C. F. Bolles, Smoker; J. G. Aldworth, Theater—Radio Television; W. G. Vieth, Hotel Accommodation; H. E. Martin, Registration and Checkup; Mrs. E. S. Banghart, Ladies' Entertainment; R. T. Weil, Monitors; J. B. Harris, Jr., Philadelphia Representative.

Milwaukee Section Meeting

On November 13, 1952, a Ladies' Night Meeting of the AIEE Milwaukee Section was held in the Allen-Bradley Company auditorium. After a buffet supper, more than 500 members and their wives saw Noel Coward's "Blithe Spirit," given by a local group

Have Trouble Presenting Technical Material? Careful Planning Important Says Lecturer

Color slides properly made and used will do much to make the presentation of technical material informative and interesting, but to be successful, careful planning is essential, according to T. H. Miller, assistant to the Director of Industrial Relations for the Eastman Kodak Company. Mr. Miller recently spoke before the Rochester section of the Photographic Society of America's Technical Division.

The basic problem stems from the fact that although technical speakers usually know their subject thoroughly, they are rarely accustomed to public speaking. Also, unfortunately, papers written for publication rarely make interesting lectures for oral presentation.

Effective presentation begins with careful planning by considering the extent of the illustrations and their careful co-ordination with the written manuscipt. As far as the production of slides is concerned, there are several factors which will help make visual aids effective. First, they must be legible, both as to general content, size, and presentation of lettering. Second, they should be reasonably simple. Simple drawings, charts, and diagrams without too many lines make it easy for people to grasp and understand the material presented. Background colors should be attractive and complementary to the principal material or drawings and should be tested photographically before use to make sure that they will reproduce attractively.

Third, title slides should be used to differentiate one section of the talk from another, and as many close-up photographs should be used as possible to eliminate possible misunderstanding. Finally, if pictures of apparatus and experiments can be personalized by including a person (preferably the speaker himself), it will be helpful in making the slides more attractive and interesting to the viewer.

When spacing slides presents a problem, text slides can be used for effective fillers and slides can be grouped by arranging the talk around them. In general, the entire operation should be planned so that the audience's attention is not called to the mechanics of the operation. This means that slides should be grouped so that it is

not necessary to turn the lights on and off a number of times during the program, or to have to call for "the next slide, please." The speaker can be assured that the slides will be keyed properly if he provides the projectionist with a copy of his paper, indicating clearly when slide changes are to take place. Also, the speaker should understand beforehand such details of the presentation as the room size, screen size, projection equipment, and signaling arrangements.

Fifth Electronic Instrumentation Conference Considers Developments in Medical Field

The newest developments in electronics and nucleonics pertaining to the medical field were explained and discussed at the fifth AIEE conference on Electronic Instrumentation and Nucleonics in Medicine at the Hotel New Yorker, New York, N. Y., November 24–25, 1952. Seventeen technical papers were presented by physicians and engineers to an attendance of 188 members and guests with the primary thought of an interchange of ideas so that each group would know the other's problems and so becoming aware of them, electromedical science would be advanced.

The opening session, with Dr. W. A. Geohegan, St. Luke's Hospital, New York, N. Y., as chairman, started with "Heating of Fat-Muscle Layers by Electromagnetic and Ultrasonic Diathermy" by H. P. Schwan, Kam Li, and E. L. Carstensen, all of the University of Pennsylvania. It was brought out that the ratios of heat developed in subcutaneous fat to that in muscle tissue by the two forms of radiant energy are quite different. The complex reflection coefficient of the fat-muscle interface has been calculated and as a result of this, it was shown that standing-wave patterns exist in subcutaneous fat if its thickness and the frequency of the radiant energy are high enough. These standing-wave patterns are not disturbing in the case of ultrasound, but they do influence the ratio of heat in fat to muscle in the case of electromagnetic radiation. Data were given for this ratio for various fat impedances, thickness of fat layer, and frequency.

The development, importance, and objectives of electrocardiography were presented by Ernest Frank, University of Pennsylvania. He explained the concept and use of the heart vector and methods of showing heart-vector functions, similar to impedance functions. He described briefly the new field of vectorcardiography.

Arthur Miller, Sanborn Company, discussed the factors affecting the accuracy of oscillographic recording systems, in which paper he brought out that it appears advantageous to study oscillographic performance in terms of response to triangular pulses rather than sinusoidal or square waveforms.

The final paper of the session, "The Technique of Recording Blood Pressure with Intravascular Miniature Manometers," was given by Dr. O. H. Gauer, Wright-Patterson Air Force Base. He described a manometer small enough (60 cubic millimeters) to be mounted at the tip of a catheter which can be introduced into the circulatory system for blood sampling and pressure recording.

New forms of instrumentation were considered in the afternoon session with Professor Ernst Weber, Polytechnic Institute of Brooklyn, as chairman. D. A. Kohl, University of Minnesota, opened the session with his paper describing a photomultiplier tube converter for low-level wide-band applications. This was followed by T. A. Rich and J. E. Bigelow, General Electric Company, explaining an oscillator-electrometer.

H. J. Morowitz and H. P. Broida, National Bureau of Standards, presented "Improved Instrumentation for Optical Spectroscopic Analysis of Isotope Mixtures." In this, it was explained how heavy-water analysis can be carried out directly on blood and other biological systems. The final paper of the session was given by W. R. Clark and R. E. Watson, Leeds and Northrup Company, in which they described a null-balance current recorder for measuring ionization currents. This instrument with a full-scale range of 10^{-10} ampere is a modification of a pH recorder and has been used with the Ohmart cell to make a sensitive instrument for unattended recording of ionization currents. They quoted an example of its use whereby tracer doses of 10 microcuries of radioiodine were recorded with a precision of $+0.3$ microcurie.

"Trends in Detection and Measurement of Radioisotopes for Medical Purposes" by J. W. Hitch, United States Atomic Energy Commission, opened the second day's morning session over which Dr. G. Failla, Columbia University, presided. This paper presented a survey of the present trends in radiation detection techniques for medical purposes under various conditions. The applicability and limitations of several types of Geiger-Mueller, proportional, and scintillation counters were given.

W. W. Schultz and R. A. Dewes, General Electric Company, described a versatile scintillation counter which is used as a probe with various heads in a slide-type sample counter or in a shielded sample counter. Another instrument described was a detector consisting of a phosphor in close contact with one or more photovoltaic cells. With no external voltage under nuclear radiation the phosphor emits light which falls on the photovoltaic cells which deliver a current. This is primarily suited to detection of high-intensity gamma and X rays.

"Light Collection and Transmission in Photoelectric Detection Devices" was given by Z. L. Collins and E. L. Webb, Westinghouse Electric Corporation. It was shown that in the case of photometers, scintillation counters, and X-ray phototimers, where the problem is to get a maximum of light into a phototube from an extended area source, the use of diffusing reflector is usually more efficient than mirror reflectors.

H. H. Rossi, Columbia University, presented "Tissue Equivalent Ionization Chambers," which was followed by "Medical Application of Ohmart Cells," by Dr. E. L. Saenger and Dr. Ji-Toong Ling, University of Cincinnati. They described two uses of the Ohmart cell. The first is a rapid method of standardization of millicurie quantities of P-32 using a gamma measuring unit by using the bremsstrahlung, which shortens the time required for the more

Lehigh Valley Section Meets

"Energy in Action," a demonstration by the Westinghouse Research Laboratories showing how mankind has utilized the unseen forces around him ultimately to develop atomic energy, highlighted the November 14, 1952, meeting of the AIEE Lehigh Valley Section in Easton, Pa. Shown here, left to right: D. A. Campbell, chairman of the Lehigh Valley Section; R. M. Wyatt, J. O. Leslie, past chairmen of the Lehigh Valley Section; Edward Green, with Westinghouse demonstration; W. B. Morton, chairman of the District 2 Meeting Committee for 1954; Robert Best, with Westinghouse demonstration; A. P. Lee, Easton Division manager; Robert Dollison, with Westinghouse demonstration

tedious plotting of absorption curves. The second use of the Ohmart cell is the development of a small highly sensitive instrument for measuring the dosage of X rays and radium in a patient. This type of cell can be introduced into many body spaces so that actual tumor dose can be determined.

Dr. T. P. Eberhard, Jefferson Hospital, Philadelphia, Pa., presided over the final session of the conference. The first paper by W. D. Bellamy, General Electric Research Laboratory, was "Some Biological Studies with High-Velocity Electrons." A resonant transformer type of X-ray unit was converted into an electron source by replacing the end of the accelerating tube with a thin electron-transparent window of stainless steel through which electrons could pass into the air. Such a tool is useful for the study of those biological effects of ionizing radiation which require many thousands of roentgens. A study of the effects of concentration and temperature on the inactivation of pepsin was described and then the results of a study of some of the factors affecting the sensitivity of bacteria to ionizing irradiation were given.

"Control and Evaluation of Air-borne Radioactive Discharge" was presented by J. J. Fitzgerald, General Electric Company. In this paper was a description of the means taken to provide maximum protection of the environs of an atomic-energy establishment from air-borne radioactive contamination. This paper was followed by "Techniques for Localized Irradiation and Dosimetry With High-Energy Deutrons" by C. A. Tobias, H. O. Anger, J. A. Sayeg, and G. P. Welch, University of California, in which the authors described the use made of the Berkeley 184-inch Cyclotron in radiobiological research carried on during the past 3 years.

The last paper of the conference, "Technical Aspects of the High-Energy Electron Beam Used in Therapy," was given by J. S. Laughlin, J. Ovadia, R. A. Harvey, and L. L. Haas, University of Illinois. The authors considered the extraction of the electron beam, its control, collimation, shielding, and monitoring, together with descriptions of several instruments and tests.

The committee in charge of this conference was headed by S. Reid Warren, Jr. The chairmen of the committees were: Local Arrangements and Registration, J. F. Zauner; Finance, J. S. Smith; Publicity, E. E. Grazda.

AIEE Board of Directors Holds October Meeting in New Orleans

A regular meeting of the AIEE Board of Directors was held in the Jung Hotel, New Orleans, La., on October 16, 1952, during the Fall General Meeting.

The minutes of the meeting of the Board of Directors held on August 21, 1952, were approved.

The following actions of the Executive Committee on membership applications, as of September 25, 1952, were reported and confirmed: 56 applicants transferred, 4 elected, and 2 re-elected to the grade of Member; 237 applicants elected and 14 re-elected to the grade of Associate Member; 41 applicants elected to the grade of Affiliate; 55 Student members enrolled.

Upon a proposal, approved by the Board of Examiners, the Board voted to invite Harold Theodore Faus to become a Fellow of the Institute.

FINANCES

Chairman Walter J. Barrett of the Finance Committee reported disbursements from the general funds for September 1952 as \$74,084.08.

A budget for the appropriation year ending September 30, 1953, as recommended by the Finance Committee, was submitted by Chairman Barrett, and was adopted by the Board.

After a discussion of the plan for appropriation payments to Branches, the Board voted to require an accounting of the expenditure of funds in the first half of the \$1.00 per member appropriation before the second payment is made, and that a final accounting be required at the end of the year.

OTHER BUSINESS

After further consideration of the handling of papers by nonmember authors and the appointment of nonmembers to committees and subcommittees, it was

VOTED that the Board of Directors continue to urge its technical committees to cultivate all portions of their specific fields including those areas which require a joint approach with other technical societies or joint work with individuals from other professional or scientific fields. In general, individuals suggested as members of technical committees should be members of the Institute and any deviation from this practice should be brought specifically to the attention of the President. However, in many cases, such as the preparation of programs or subcommittees' work done by task forces recruited for specific projects, contribution of papers or subcommittee participation by individuals not members of the Institute are of value and may be utilized. The Board delegates to its Committee on Technical Operations the authority for approval of participation of nonmembers as authors of papers and members of subcommittees excepting subcommittee chairmen who are included above as members of the technical committee. At the discretion of the CTO, this authority may be redelegated to the technical division committee concerned.

Chairman Elgin B. Robertson of the Committee on Planning and Co-ordination reported that the committee has under consideration the effects of special technical conferences on general and District meetings, and the possible desirability of rearranging the geographical Districts to provide for better administration as the Institute grows.

The Board approved for submission to the membership two proposed amendments to the Constitution. One would enlarge the Nominating Committee to include a representative of each technical division. The other would increase the number of members of the Committee of Tellers from 7 to 10.

A proposed form of badge for award in recognition of the services of past chairmen of Sections was approved, as recommended by the Sections Committee in a report presented by Chairman C. S. Purnell.

Upon recommendation of the Executive Committee of the Chicago Section, it was voted that the AIEE serve as a sponsor of the American Power Conference. In the past the Chicago Section has been a sponsor.

Several Board members presented brief reports upon various joint activities.

It was decided to hold the next meeting of the Board of Directors at Institute headquarters on Thursday, January 22, 1953, during the Winter General Meeting, January 19–25, and to hold the April meeting in Louisville, Ky., on Thursday, April 23, 1953, during the Southern District Meeting.

APPOINTMENTS

Members of the Board of Directors were selected as members and alternates to represent the Board on the AIEE Nominating Committee, as follows:

Members—R. F. Danner, M. D. Hooven, N. C. Pearcy, C. S. Purnell, W. R. Way

Alternates—E. W. Davis, C. M. Lytle, J. C. Strasbourger

As it is expected that, beginning in 1953, representatives on the Engineers Joint Council will be appointed by the societies rather than on the present ex officio basis, appointments were made as follows:

Representatives—Walter J. Barrett, H. H. Henline T. G. LeClair

Alternates—M. D. Hooven, C. S. Purnell

T. M. Linville was reappointed AIEE representative on the Alfred Noble Prize Committee for a term of 5 years beginning January 1, 1953.

CHANGES IN OFFICERS

As a result of his appointment as Assistant Secretary of the Institute, Dean N. S. Hibshman resigned as Treasurer, effective January 1, 1953.

Walter J. Barrett was elected Treasurer, effective January 1, 1953, for the remainder of Dean Hibshman's term ending July 31, 1953.

L. F. Hickernell was elected a Director, effective January 1, 1953, for the remainder of Mr. Barrett's term ending July 31, 1954.

Subsequently, President Quarles appointed C. S. Purnell Chairman of the Finance Committee for the remainder of the administrative year ending July 31, 1953.

ATTENDANCE

Present at the meeting were: *President* D. A. Quarles; *Past President* F. O. McMillan; *Vice-Presidents* W. L. Cassell, W. Scott Hill, M. D. Hooven, E. S. Lammers, Jr., N. M. Lovell, F. W. Norris, J. S. Strasbourger, W. R. Way; *Directors* Walter J. Barrett, F. R. Benedict, R. F. Danner, E. W. Davis, D. D. Ewing, A. C. Muir, N. C. Pearcy, C. S. Purnell, Elgin B. Robertson, Victor Siegfried; *Treasurer* N. S. Hibshman; *Secretary* H. H. Henline.

District 4 Executive Committee Holds Meeting in New Orleans

The Executive Committee of AIEE District 4 (Southern) met in New Orleans, La. on October 17, 1952. Some 33 of the committee's 37 members were present.

Vice-President E. S. Lammers, Jr., highlighted the importance of the District and its work and emphasized the importance of

Members of the District 4 Executive Committee who attended the October 17 meeting in New Orleans, La., were, front row, left to right: W. H. Hickey, Jr., Georgia Section; F. H. Pumphrey, Sections Committee; T. R. Brock, Mississippi Section; C. P. Knost, Sections Committee; E. S. Lammers, Jr., Vice-President, District 4; C. P. Almon, Jr., Secretary, District 4; H. A. Schaeffer, New Orleans Section; B. Z. Segall, New Orleans Section; M. G. Northrop, Student Activities Chairman. Second row, left to right: E. V. McMahon, Georgia Section; R. L. Poor, Miami Section; R. E. Walker, Jacksonville Section; C. R. Vail, North Carolina Section; W. L. Garlington, Jacksonville Section; V. E. Mohler, Memphis Section; W. C. Burnett, North Carolina Section; W. H. Lee, Oak Ridge Section; G. A. Holt, Oak Ridge Section; J. W. Graff, Alabama Section; R. B. Sanderford, Nashville Section. Back row, left to right: Oran Long, South Carolina Section; J. D. Warren, Louisville Section; P. R. Spracher, Virginia Section; E. C. Gentle, Jr., Alabama Section; R. H. Stevens, Miami Section; W. C. Jordon, Jr., Memphis Section; V. D. Almond, Nashville Section; Mead Warren, East Tennessee Section; E. R. Coulbourn, District 4 Vice-Chairman of Membership Committee; J. W. Roberts, East Tennessee Section; J. L. Maxwell, Mississippi Section. Also present, but not shown, were E. W. Woody, Virginia Mountain Section, and J. G. Lips, Louisville Section

the meeting as a place to discuss AIEE problems. E. R. Coulbourn, Vice-Chairman of the District Membership Committee, pointed out the 14.7 per cent membership gain in District 4 is well above the average. He stressed that qualified electrical engineers should join the AIEE because the Institute is the best professional society in the United States, it is a leader in all joint projects sponsored by the Founder Societies, and its members benefit by the papers and experience of leading men in the field. Institute growth and the technique of handling applications were discussed also.

As representative for the Sections Committee, Professor F. H. Pumphrey gave detailed constructive suggestions regarding each of the major activities of the Sections, for example: (1) induce the Sections to present programs showing what they are doing; (2) make people feel at home at the meetings; (3) publish the names of the officers, and also announcements of meetings; (4) hold special meetings for special groups; (5) budget your time so that you can carry out your AIEE responsibilities; (6) work for the professional advancement of the Institute.

Professor M. G. Northrop, chairman of the Committee on Student Activities, called attention to the cards being sent from AIEE Headquarters to the Sections showing the location of newly graduated electrical engineers. He suggested that the interests of these graduates be developed as they come into the areas and that they receive meeting notices. The next student meeting will be held with the Southern District Meeting in Louisville, Ky., April 22–24, 1953. A motion for each Section to provide $25 to help finance this student meeting was carried, and a brief report was made on the April 1952 student meeting at Tulane University.

An open discussion brought out the methods used by certain of the Sections in technical group activities, publicity, raising the level of membership grades, and correlation of student activities with those of the Section. C. P. Knost, of the Sections Committee, commented on some of the points discussed, and outlined in detail the formation of a Subsection.

The procedure on the promotion of prize papers by Sections and by the students was discussed by Director C. S. Purnell, and Vice-President Lammers reviewed the pending action whereby there will be a reduction in Affiliate and Associate Member fees until a certain specified age has been reached. He further stated that suggestions on realignment of Districts are being studied.

Mr. Lammers was elected as District 4 representative on the National Nominating Committee, and it was voted that Mr. Knost is to be supported for Director. C. P. Almon, Jr., District 4 Secretary, was nominated for Vice-President of the District. The next Executive Committee meeting will be held in Birmingham, Ala., or Charlotte, N. C.

Recorders and Controllers Discussed at Recent Conference

A special Technical Conference on Electrically Operated Recorders and Controllers, the first ever to be held on this subject, met at the Benjamin Franklin Hotel, Philadelphia, Pa., on November 17 and 18, 1952. The conference was sponsored by the Subcommittee on Recording and Controlling Instruments of the AIEE Instruments and Measurements Committee, with the participation of the Industrial Instruments and Regulator Division of The American Society of Mechanical Engineers and the Instrument Society of America.

The 2-day conference attracted a total registration of 515 representing all classes of users including the oil, chemical, textile, steel, and rubber industries; public utilities; transportation; schools and colleges; government agencies and research laboratories; as well as the instrument manufacturers.

Breakfast meeting of the national and local committees, together with some of the speakers, at the Philadelphia Conference on Electrically Operated Recorders and Controllers

The program was comprised of four technical sessions devoted, respectively, to new developments in the field of self-balancing recorders, electric controlling instruments, applications and systems, and new recording instruments. The titles of the 17 papers presented, together with a brief summary of each, were included in the conference program which appeared in the October issue (*EE, Oct '52, pp 948–9*).

At the dinner on Monday evening, J. D. Rollins, United States Steel Corporation, spoke on "The Broad Aspects of a New Integrated Steel Plant," with particular reference to the new Fairless steel plant under construction near Philadelphia. The toastmaster was E. S. Lee, past president of the AIEE. The Monday luncheon was addressed by Bennie Bengough, baseball coach of the Philadelphia National League Club, who described "Thirty-Five Years of Baseball." At the Tuesday luncheon, R. M. Pennypacker, Philadelphia Electric Company, discussed "The British Electricity Industry." Mr. Pennypacker recently returned from a 6-week visit to Great Britain as a member of a study panel representing the public utilities of the United States.

The committee chairmen and vice-chairmen in charge of the conference were as follows:

G. L. Broomell, General Con erence Committee Chairman; A. J. Hornfeck, Program Chairman; P. A. Borden, Program Vice-Chairman; T. L. Mell, Sessions Chairman, Proceedings Chairman; E. A. Adler, Sessions Vice-Chairman; E. F. Adams, National Publicity Chairman; J. W. Percy, National Publicity Vice-Chairman; E. S. Bristol, Philadelphia Publicity Chairman; E. G. Althouse, Philadelphia Publicity Vice-Chairman; H. Bany, Finance Chairman; S. R. Folger, Finance Vice-Chairman; W. Speer, Hotel and Space Chairman; F. Hershey, Hotel and Space Vice-Chairman; S. E. Moore, Local Arrangements Chairman; R. Hewett, Local Arrangements Vice-Chairman, Registrations Chairman; F. Zimmerli, Registrations Vice-Chairman; R. S. Gardner, AIEE Headquarters

photo by David Hansbrough

Shown at the banquet which preceded the recent joint meeting of the St. Louis Section and Student Branches in the St. Louis area are left to right: Darrel Karl, Student Chairman, St. Louis University, Institute of Technology; J. S. Malsbary, Chairman, St. Louis Section; G. F. McCormick, Sudent Branch Chairmain, Missouri School of Mines; G. J. Fiedler, Sverdrup and Parcel, Inc.; and John Jordan, Student Branch Chairman, University of Missouri

Schenectady Section Is Host to Machine Tool Conference

Some 400 electrical engineers from the machine tool and metal-working industries attended the fifth annual Machine Tool Conference sponsored by the Machine Tool Subcommittee of the AIEE General Industry Applications Committee. With the AIEE Schenectady Section as host, the conference was held October 29–31, 1952, at the Hotel Ten Eyck, Albany, N. Y.

Machine tool drive applications were the subject of the papers presented at the technical session on Wednesday afternoon. On Wednesday evening, the annual banquet attracted approximately 300 persons. Principal speaker was Tell Berna, general manager of the National Machine Tool Builders Association, who discussed "The Machine Tool Industry at the Crossroads." Mr. Berna recently returned from a 6-week survey of the European machine tool industry and his address included interesting comments on the problems faced by the machine tool manufacturers of the United States when competing in world markets against British, German, Italian, Swiss, French, and other European machine tool builders.

The Thursday morning technical conference was devoted to the problems of operator safety and electrical code requirements as they apply to machine tools. At the Thursday luncheon, H. A. Winne, General Electric Company, presented a thought-provoking talk on "Future Prospects for Atomic Electric Power Plants." The final technical session was held on Thursday afternoon.

Friday, October 31, was reserved for a series of inspection trips to the Watervliet Arsenal and the Schenectady Works of the General Electric Company. Manufacturing areas visited at General Electric included steam turbine and generator, gas turbine, induction motor, and electronic and magnetic control.

At the conclusion of the conference, plans were announced for the sixth annual conference to be held in Cleveland, Ohio.

Members of the Subcommittee on Machine Tools are: J. M. Delfs (*Chairman*), R. H. Clark (*Vice-Chairman*), R. W. Brown, B. T. Anderson, E. K. Rivoira, T. A. Wetzel, D. R. Percival, W. J. Piper, C. G. Helmick, J. J. Jaeger, K. O. Tech, V. R. Murphy, R. T. Fenn, E. F. Mekelburg, S. I. Rice, R. E. Stroppel, W. B. Wigton.

Missouri Student Branches Meet With St. Louis Section

With the Student Branch from the Missouri School of Mines and Metallurgy at Rolla, Mo., as host, the AIEE St. Louis Section held its annual joint meeting with the Student Branches in the St. Louis,

(Left) Shown registering at the recent AIEE Machine Tool Conference in Albany are, left to right: E. W. Knight, Elliott Company; and R. W. Reese, D. S. Brereton, H. J. Wulfken, E. A. Brown, and Donald Eldred, all of the General Electric Company. The receptionists are all members of the staff of General Electric's Industrial Engineering Department. (Right) Some of the principal speakers confer with the chairman of the conference. Left to right: V. R. Murphy, Reliance Electric and Engineering Company; K. O. Tech, Cross Company; J. L. Dutcher, General Electric Company; J. M. Delfs, conference chairman; E. J. Rivoira and J. M. Morgan, Cincinnati Milling Machine Company

Mo., area on October 31, 1952. The total attendance of 110 persons included 45 from the host Student Branch, 18 from the St. Louis Section, 18 from Missouri University at Columbia, 15 from St. Louis University, and 14 from Washington University in St. Louis. The meeting was preceded by a banquet.

Featured speaker of the evening was G. J. Fiedler, chief instrumentation engineer for Sverdrup and Parcel, Inc., of St. Louis, who discussed "Instrumentation and Control of Guided Missiles." Within the limits of security regulations, he described the application of optical, radar, radio dappler, telemetering, and computing equipments to the flight testing of missiles.

Other speakers at the meeting were Professor I. H. Lovett, chairman of the Electrical Engineering Department of the Missouri School of Mines, who gave the welcoming address; J. S. Malsbary, chairman of the St. Louis Section, who thanked the host Branch for its work in holding the meeting; and R. C. Hase, chairman of the Section's Student Activities Committee, whose topic was the Student Branches and their activities.

The next joint meeting will be held in the fall of 1953 at Columbia, Mo., with the University of Missouri Student Branch acting as the host.

Third Subsection Organized by North Carolina Section

The third Subsection of the AIEE North Carolina Section was organized at a meeting held November 12, 1952, at North Carolina State College in Raleigh, N. C. Plans for the Subsection were the result of a survey conducted by J. A. Jones which disclosed a strong demand for local meetings by the approximately 100 Institute members located in the area around Raleigh.

Forty-three persons attended the organizational meeting which was presided over by W. C. Burnett, chairman of the North Carolina Section. Temporary officers elected for the Subsection were K. T. Knight as chairman and A. J. Hill as secretary-treasurer. Professor C. R. Vail (Chairman), N. H. Erlandson, and C. R. Webster were appointed as a committee to draw up bylaws for the group.

No name has been chosen for the new Subsection as yet, but it is expected that it will encompass an area of from 50 or 60 miles in radius around Raleigh. Industrial growth and an intensive membership campaign are expected to produce a considerable increase in the number of AIEE members in the vicinity.

Shown at the organization meeting of the new Subsection of the North Carolina Section are, left to right: A. A. Johnson of the Westinghouse Electric Corporation, speaker of the evening; W. C. Burnett, chairman of the North Carolina Section; K. T. Knight, temporary chairman of the new Subsection; C. R. Vail, secretary-treasurer of the North Carolina Section; A. J. Hill, temporary secretary-treasurer of the new Subsection

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Communication Division

Committee on Telegraph Systems (*E. C. Chamberlin, Jr., Chairman; J. A. Duncan, Jr., Vice-Chairman; R. B. Shanck, Secretary*). In addition to a session on wire and cable for use in the telegraph industry scheduled for the Winter General Meeting, an interesting technical session in the field of facsimile is being planned for the 1953 Summer General Meeting at Atlantic City, N. J., which will emphasize modern methods of pictorial transmission. It is hoped that European organizations can be prevailed upon to participate in the presentation of an international session on the subject.

A committee meeting is planned during the course of the Winter General Meeting to develop agenda for the coming year.

Industry Division

Committee on Mining and Metal Industry (*A. C. Muir, Chairman; W. R. Harris, Vice-Chairman*). The Committee on Mining and Metal Industry sponsored two sessions on "Taconite" at the Summer General Meeting in Minneapolis, Minn., June 1952. These sessions were arranged jointly by the Western Mining Subcommittee and the Minerals Beneficiation Subsection of the Minnesota Section of the American Institute of Mining and Metallurgical Engineers (AIME). Papers were presented by members of AIME and AIEE.

The Western Mining Subcommittee sponsored two sessions at the Pacific General Meeting in Phoenix, Ariz., August 1952, on "Electrical Applications in Hard Rock Mining."

The Mining and Metal Industry Committee with the help of its planning group is working out plans to spread the work of the committee to cover the development of programs for future meetings, study of standards, reports of papers presented, review of papers, and the promotion of special technical conferences. Each committee member will be given an assignment. The committee hopes that by this means work can be accomplished for the Institute in the many fields other than the presentation of papers at meetings.

The Eastern Mining Subcommittee is co-operating with the District Meeting Committee in planning a session for the District 2 meeting to be held in Charleston, W. Va., October 1953.

Power Division

Committee on Rotating Machinery (*C. G. Veinott, Chairman; E. I. Pollard, Vice-Chairman; L. W. Buchanan, Secretary*). The Induction Machinery Subcommittee has formed a working group to establish standard nomenclature for induction machine constants.

Two working groups of the Insulation Subcommittee have been active and are approaching completion of their tasks. Final drafts of the "Insulation Maintenance Guide for Large A-C Rotating Machinery" and a new test code for the "Functional Evaluation of Electrical Insulation for Random Wound Machines" will be presented as conference papers at the Winter General Meeting.

The Electric Coupling Subcommittee has prepared a bibliography on electric couplings and proposes to publish it in the form of a *Transactions* paper.

A standing-room-only sign had to be hung up at a very successful all-day symposium on design of double-cage rotor motors held at the Middle Eastern District Meeting at Toledo, Ohio, October 29, 1952. The success of this symposium seemed to indicate to those present the value of integrated sessions planned around a given subject. Many suggestions for suitable subjects for future symposia were developed at this meeting.

Committee on Switchgear (*R. L. Webb, Chairman; J. D. Wood, Vice-Chairman; J. M. Gieger, Secretary*). The Committee on Switchgear has six active subcommittees at work on Power Circuit Breakers, Low-Voltage Air Circuit Breakers, Switches, Fuses, and Insulators, Automatic Circuit Reclosers, Switchgear Assemblies, and Administration. A seventh subcommittee on Network Protectors is awaiting the completion of work on this subject by a separate joint industry committee.

The committee held a meeting on November 21, 1952, at which the status of

work in the several subcommittees was reported as follows:

Power Circuit Breakers. Subject to letter-ballot, two additions were approved for the Standards, namely, (*a*) "Recommendations on Simplified Calculation of Short Circuits," for *C37.5*, and (*b*) "Temperature Rise of 35 Degrees Centigrade for Contacts of Oilless Circuit Breakers," for *C37.4.* Good progress was reported on the job of setting up proposed Power Circuit Breaker Standards with the necessary revisions to incorporate the Symmetrical Method of Rating. Work is underway on generator neutral circuit breaker application, duty cycle of high-voltage circuit breakers, line charging current interruption, and other such problems.

Low-Voltage Air Circuit Breakers. Subject to letter-ballot, it was agreed that Standard Number *20* should have a paragraph inserted to state its requirements do not apply to molded case circuit breakers. Similar action was taken regarding application of 40-degree-centigrade rise for silver-surfaced contacts and terminals in Paragraph *20–250.* A new assignment was accepted on the proposed preparation of a guide for the calculation of d-c fault currents and the application of air circuit breakers on d-c systems. The subcommittee also will investigate the matter of AIEE Standards for Molded Case Circuit Breakers.

Switches, Fuses, and Insulators. Reports were received on Load Interrupter Switch progress toward Standards, Low-Voltage Fuse progress, Guide on Ice Testing of Disconnect Switches, work on Silver-to-Copper Contacts, Co-ordination of Switch Short-Time Current Ratings, and Standard Temperature Tests.

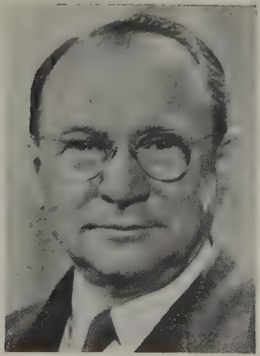
Automatic Circuit Reclosers. Standard Number *50* revised is in the hands of the Standards Committee. The subcommittee will look into the need for Sectionalizing Switch Standards. It will explore also the need for a guide on Capacitor Switching, jointly with the Power Circuit Breaker Subcommittee.

Switchgear Assemblies. The major problem is solar heating of outdoor metalclad gear. Results of tests were presented and definite test procedures have been agreed upon. There is much work ahead on this important subject.

The Switchgear Committee will sponsor three technical sessions at the Winter General Meeting concerning oil and gas interrupting media, power circuit breakers, low-voltage air circuit breakers, switches, American and British rating methods, circuit recovery voltages, and switchgear assemblies.

AIEE PERSONALITIES.....

V. K. Zworykin (M '22, F '45) has been awarded the 1952 Edison Medal "for outstanding contributions to the concept and design of electronic components and systems." Dr. Zworykin, who is vice-president, technical consultant, and director of electronic research, RCA Laboratories Division, Radio Corporation of America, Princeton, N. J., will receive the medal during the AIEE Winter General Meeting at the general session on January 19, 1953. Born in Mourom, Russia, July 30, 1889, Dr. Zworykin was educated at the Petrograd Institute of Technology. Following a period of graduate work in Petrograd, during which he performed his first experiments with television and began to realize the potentiality of cathode-ray tubes, he went to Paris in 1912 to enroll at the College de France. At the close of World War I he came to the United States, joining the research staff of the Westinghouse Electric Corporation, East Pittsburgh, Pa. While with Westinghouse, he carried out investigations in the field of photoelectric emission. He also resumed his research in television, developing the basic principles of the iconoscope. In 1929 Dr. Zworykin became Director of the Electronic Research Laboratory of the Radio Corporation of America. He was appointed to his present position in 1947. His work led to the development of the Kinescope television picture tube, secondary emission multipliers, and image tubes, as well as the electron microscope. He has received two degrees since coming to the United States: doctor of philosophy, in 1926, from the University of Pittsburgh, and doctor of science, in 1938, from the Polytechnic Institute of Brooklyn. Some of the awards he has received for scientific achievements are: the Lamme Medal for 1948 from the AIEE; the Morris Liebmann Memorial Prize, 1934; the Overseas Award from the British Institution of Electrical Engineers, 1939; the Rumford Medal from the American Academy of Arts and Sciences, 1941; the National Modern Pioneer Award, 1940; the Howard N. Potts Medal from the Franklin Institute, 1947; the Poor Richard Club Gold Medal for Achievement, 1949; Chevalier Cross of the French Legion of Honor, 1949; the Progress Medal award and honorary membership of the Society of Motion Picture and Television Engineers, 1950; and the Institute of Radio Engineers Medal of Honor, 1951. In recognition of his contribution to victory in World War II, he received the Presidential Certificate of Merit, the War Department Certificate of Appreciation, and the Navy Certificate of Commendation. In 1950, Dr. Zworykin was admitted as Eminent Member into Eta Kappa Nu. Dr. Zworykin is a member of the National Academy of Sciences, the American Academy of Arts and Sciences, the American Philosophical Society, the National Research Council, Sigma Xi, the Electron Microscope Society of America, and an officer of the French Academy of Science. He is a fellow of the Institute of Radio Engineers, the American Physical Society, and the American Association for the Advancement of Science. He is the author of several books on photocells, television, electron optics, and photoelectricity.



V. K. Zworykin

J. F. Fairman (AM '20, F '35), Administrator, Defense Electric Power Administration (DEPA), Washington, D. C., was presented recently with a citation by Oscar L. Chapman, Secretary of the Interior, on the occasion of Mr. Fairman's retirement as head of DEPA. The citation is for "distinguished service in recognition of outstanding leadership and exemplary service in the furtherance of the national security and defense," the text of which reads as follows: "After serving as Deputy Administrator, Mr. Fairman succeeded to the position of Administrator of the Defense Electric Power Administration at the time when the vital need to expand the Nation's electric power generating capacity for the defense and protection of our economy was not generally recognized. While skillfully distributing the insufficient allotments of available materials and equipment to power projects to the best advantage of the expansion program, he developed and carried on an effective educational campaign to bring about full realization of the need to enlarge the country's power potentials to keep pace with industry expansion. With his aid there was a complete reversal from the opinion that the expansion program established by the power industry was exorbitant. By a realistic approach to gain recognition of the expansion program, power was placed among the industries basically essential to our defense and protection. As a result, he relieved to an appreciable extent the withholding of scarce materials and equipment needed by power projects to reach their goals. In an industry fraught with a divergence of opinion on the matter of ownership of power supply facilities, Mr. Fairman, through his inspiring leadership and fairness, obtained unparalleled unity of

J. F. Fairman

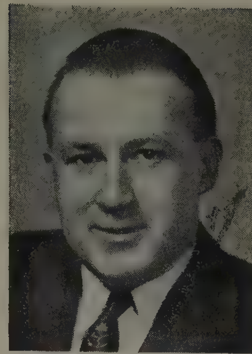
effort and purpose. For his excellent leadership, vigorous patriotism, and outstanding service to the Nation, the highest tribute of the Department of the Interior, its Distinguished Service Award, is granted to Mr. Fairman." The presentation was made by the Secretary of the Interior on November 24, 1952, in Washington. Mr. Fairman, a vice-president of Consolidated Edison Company of New York, Inc., was appointed Deputy Administrator of DEPA by Secretary Chapman on April 2, 1951, and on July 1, 1951, was named by the Secretary to succeed Clifford B. McManus of Atlanta, Ga., as Administrator. His resignation was effective November 30, 1952, when he returned to his duties as vice-president of Consolidated Edison. Mr. Fairman was president of the AIEE, 1949–50, and has served the Institute in many capacities.

J. W. McRae (AM '37, M '50), vice-president, Bell Telephone Laboratories, New York, N. Y., has been elected president of the Institute of Radio Engineers for 1953. Dr. McRae was born on October 25, 1910, in Vancouver, British Columbia, Canada. He received his bachelor of science degree in electrical engineering from the University of British Columbia in 1933, the master of science degree in 1934 from California

J. W. McRae

Institute of Technology, and his doctor of philosophy degree from the same institution in 1937. Early in 1937 he joined the staff of Bell Telephone Laboratories, Inc., where he engaged in research on transoceanic radio transmitters. After serving for 3 years in the United States Army Signal Corps during World War II, where he attained the rank of colonel and received the Legion of Merit for his services, he returned to Bell Telephone Laboratories and was appointed director of electronic and television research in February 1947. He became director of transmission development in October 1949, and on June 1, 1951, Dr. McRae was appointed vice-president in charge of the systems development organization. He is a fellow of the Institute of Radio Engineers and a member of Sigma Xi.

D. L. Herr (M '47), head, research and development, Production Co-ordination Department, Hughes Aircraft Company, Culver City, Calif., has been elected president and a director of American Electronic Manufacturing, Inc., Los Angeles, Calif. Mr. Herr was graduated from the University of



D. L. Herr

Pennsylvania in 1937 with a bachelor of science degree in electrical engineering. In 1938–39 he was selected National Tau Beta Pi Fellow and did advanced work at the Massachusetts Institute of Technology. Mr. Herr served as Officer-in-Charge of the Electrical Minesweeping Section of the Bureau of Ships, United States Navy, during World War II. After the war Mr. Herr was assistant to the vice-president in charge of engineering of the Control Instrument Company, Brooklyn, N. Y.; senior engineer of the Reeves Instrument Corporation, New York, N. Y.; and head of research and development, Hughes Aircraft Company. In 1950 he was awarded one of the A. Cressy Morrison prizes by the New York Academy of Sciences for his paper on "A Theorem in Electromagnetics, with Useful Applications to Computing Devices." Mr. Herr is a member of the Institute of Radio Engineers, New York Academy of Sciences, American Society of Mechanical Engineers, Institute of the Aeronautical Sciences, American Association for the Advancement of Science, Sigma Xi, Tau Beta Pi, and Eta Kappa Nu.

C. N. Metcalf (M '46) has returned to Consolidated Edison Company of New York, Inc., New York, N. Y., after completing a 10-month assignment with the Defense Electric Power Administration, Washington, D. C., as Power Analyst in the Power Supply Division. He is Engineer, Transmission and Distribution Bureau, Electrical Engineering Department, with Consolidated Edison. Mr. Metcalf holds the rank of Commander, Civil Engineering Corps, United States Naval Reserve, and served as head of the Electrical Section, Advanced Base Department, Bureau of Yards and Docks in Washington, D. C., in 1944–45. Mr. Metcalf is being succeeded in his duties with the Defense Electric Power Administration by **E. C. Brown** (AM '26, M '43), assistant to the president, Hartford (Conn.) Electric Light Company.

C. R. Burrows (AM '26, F '45), director of the School of Electrical Engineering, Cornell University, Ithaca, N. Y., has been elected vice-president of the International Scientific Radio Union for a 2-year term. He was re-elected president of its Commission II on Tropospheric Propagation. Dr. Burrows headed the United States delegation to the 10th general assembly of the Union in Sydney, Australia. He has served on the AIEE committees on Basic Sciences (1947–52) and Research (1947–53), and is a fellow of the Institute of Radio Engineers and the American Physical Society. Also in the delegation to the meeting were **A. H. Waynick** (AM '45, M '49), director of the Department of Electrical Engineering, Pennsylvania State College, State College; **F. J. Gaffney** (AM '37), manager of the Polytechnic Research and Development Company, Brooklyn, N. Y.; and **H. E. Dinger** (M '48), Naval Research Laboratory, Washington, D. C. Dr. Waynick is secretary of the United States National Committee of the International Scientific Radio Union and has served on the AIEE Basic Sciences Committee (1949–52). Mr. Gaffney was a member of the Instruments and Measurements Committee of the Institute from 1947–52.

R. M. Stronach (M '48), Captain, United States Air Force Reserve, and Chief, Electronic and Instrument Section, Production and Resources Division, Air Material Command, Wright-Patterson Air Force Base, Ohio, has been appointed also Chief of the Electronic and Instrument Section, Components and Equipment Branch, Aircraft Production Resources Agency. Reference is made to Captain Stronach and his functions with the Air Material Command in the August 4, 1952, issue of *Aviation Week*. Captain Stronach received his bachelor of science degree in engineering from Brown University and his bachelor of business administration from Northeastern University. He is also a graduate of Wentworth Institute and the Lowell Institute School of the Massachusetts Institute of Technology. A native of Lowell, Mass., he is a registered professional engineer in that state and has been associated with the New England Electric System since 1938.

H. T. Brinton (AM '23), vice-president, Phelps Dodge Copper Products Corporation, New York, N. Y., has been elected president of the company, which is fabricating subsidiary of the Phelps Dodge Corporation. Mr. Brinton entered the wire and cable business in 1912 when he became employed at the Yonkers, N. Y., plant of the Habirshaw Wire and Cable Company, predecessor to the present Habirshaw Division of the Phelps Dodge Copper Products Corporation. In 1932 he was named sales manager of the company and in 1937 was elected vice-president. He is a member of the Wire Association, Army Ordnance Association, National Security Industrial Association, and the Advisory Committee of the National Production Authority and Office of Price Stabilization, Washington, D. C.

H. D. Wills (AM '51), engineer, Chattanooga (Tenn.) Implement and Manufacturing Company, and **W. D. Plengey** (AM '46), instructor in electrical engineering, North Carolina State College, Raleigh, have joined the staffs of the electromagnetic plant and gaseous diffusion plant, respectively, of the atomic energy installations operated by Carbide and Carbon Chemicals Company, Oak Ridge, Tenn.

J. H. Foote (AM '18, F '32), president, Commonwealth Services, Inc., Jackson, Mich., has been awarded a certificate of service by the American Standards Association (ASA) in recognition of his work in the development of American Standards. Mr. Foote is a member of the ASA Standards Council, representing the American Society for Testing Materials. He is also active in ASA affairs as a representative of the AIEE and the electric light and power groups. Mr. Foote has served on the following Institute committees: Power Transmission and Distribution (1929–31); Protective Devices (1932–34); Power Generation (1936–46); Domestic and Commercial Applications (1940–41); Registration of Engineers (1946–53); Standards (1947–50); Insulated Conductors (1947–49); and Liaison Representative on Standards Council (1951–53).

W. C. Smith (AM '18, F '49), special studies engineer, Michigan Bell Telephone Company, Detroit, has retired after 34 years of service. Born in Manahawkin, N. J., July 5, 1887, he was graduated from Union College in 1914 with a bachelor of electrical engineering degree and received the degree of master of science in electrical engineering there the following year. Before coming to the Michigan Bell Telephone Company in 1918, he was in charge of the electrical department of the Elmira (N. Y.) Vocational School, assistant professor of electrical engineering at Texas Agricultural and Mechanical College, College Station, and in charge of advanced technical training for Signal Corps telephone technicians at the University of Michigan, Ann Arbor. A former vice-president of District 8 (1941–43) and director (1945–49), Mr. Smith has served on the following AIEE committees: Code of Principles of Professional Conduct (1940–44); Constitution and Bylaws (1945–51, Chairman, 1947–49); Student Branches (1945–47); Planning and Co-ordination (1947–49); and Sections (1949–51).

L. S. Brumgard (M '49), sales engineer, General Electric Company, Philadelphia, Pa., has been appointed manager of the company's apparatus sales office in Trenton, N. J. He will replace **E. H. Powell** (AM '48), who will assume the duties of assistant manager at the General Electric apparatus sales office in Richmond, Va. A native of Littlestown, Pa., Mr. Brumgard was graduated from Pennsylvania State College in 1937 and joined General Electric the same year. After various assignments in engineering and sales at Schenectady, N. Y., Philadelphia and Pittsburgh, Pa., he transferred in 1946 to the Philadelphia office as a cable specialist. Mr. Powell is a native of Newell, W. Va., and received his degree in electrical engineering from the University of Pittsburgh in 1926. After 2 years as a student engineer, he joined lighting sales at Schenectady, N. Y., transferring to Syracuse, N. Y., in 1929 as a lighting specialist. In 1932 he went to Philadelphia in the same capacity, and in 1947 moved to Wilmington, Del., for general sales work. From November 1949 until his present appointment, Mr. Powell managed the Trenton apparatus sales office.

J. L. Callahan (M '35, F '48), assistant to director, Radio Systems Research, RCA Laboratories Division, Radio Corporation of America, New York, N. Y.; **Ferdinand Hamburger, Jr.**, (AM '26, F '48), professor of electrical engineering, Johns Hopkins University, Baltimore, Md.; **E. J. Isbister** (AM '34, M '47), radar engineering department head, Sperry Gyroscope Company, Great Neck, N. Y.; **E. C. Jordon** (M '45), professor of electrical engineering, University of Illinois, Urbana; **R. G. Kloeffler** (AM '21, F '32), Head, Department of Electrical Engineering, Kansas State College, Manhattan; **Walther Richter** (M '37, F '42), consulting engineer, Milwaukee, Wis.; **A. W. Straiton** (M '44), professor of electrical engineering and director of research laboratory, University of Texas, Austin; and **Irven Travis** (M '46), director of research, Burroughs Adding Machine Company, Philadelphia, Pa., have been named fellows of the Institute of Radio Engineers by the Board of Directors. The award of fellow is bestowed on members who have made outstanding contributions to radio engineering or allied fields.

Erling Frisch (M '49), manager, control engineering, Atomic Power Division, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been awarded $200 for the Division's "most meritorious patent disclosure" of recent date. A native of Oslo, Norway, Mr. Frisch joined Westinghouse at East Pittsburgh in 1923 and held various engineering positions in the company's Switchgear Division aiding in the design and construction of electric control equipment. He was assigned to the Atomic Power Division staff in August 1949 and has applied his talents to the problems involved in the design and construction of the atomic engine for submarine propulsion.

H. S. Dixon (AM '35, M '43), University of California, Berkeley, has been appointed Chairman of the Electrical Engineering Department, Newark (N. J.) College of Engineering. Dr. Dixon received his bachelor of arts degree and did postgraduate work at Stanford University and received his doctorate from Purdue University this spring. During the war years he did aircraft electrical engineering work for Douglas Aircraft Company and North American Aviation. He had been chairman of Electrical Engineering at North Dakota State College, Fargo. He is a member of Tau Beta Pi, Sigma Xi, Eta Kappa Nu, the National Society of Professional Engineers, and the National Education Association. He has served the AIEE on the committees on Registration of Engineers (1948–49) and Student Branches (1950–51).

A. L. O'Banion (AM '21, F '50), superintendent, Fire Alarm Division, Fire Department, Boston, Mass., received the 1952 award of the Edwards Company of Norwalk, Conn., "for outstanding public service in the field of fire protection." The award was made before the opening session of the 57th annual convention of the International Municipal Signal Association in Boston. Mr. O'Banion was chairman of the Boston Section of the AIEE in 1944–45 and has served on the Sections Committee of the Institute (1949–51).

W. J. Fleming (AM '43), manager of engineering and manufacturing, General Electric X Ray Department, Milwaukee, Wis., has been appointed general manager of the company's Lighting and Rectifier Department, Schenectady, N. Y. Born in Paint Township, Pa., Mr. Fleming was graduated from Pennsylvania State College in 1923 and joined General Electric the same year. He is a member of Tau Beta Pi, Eta Kappa Nu, and the National Electrical Manufacturers' Association. He has served on the Industrial Control Devices Committee of the AIEE (1945–47).

Frederick Krug (AM '17, F '36, Member for Life), general manager, Montreal Engineering Company, Montreal, Quebec, Canada, has been appointed vice-president of International Power Company, Ltd., Montreal. Mr. Krug has been a director of International Power since 1945. He will continue as general manager of Montreal Engineering. Mr. Krug has served the Institute on the Membership (1943–45) and Sections Committee (1943–46).

D. R. Jenkins (AM '49), application engineer, Westinghouse Electric Corporation, Salt Lake City, Utah, has been appointed manager of the gas turbine application engineering section of the Steam Division of the Westinghouse Electric Corporation, South Philadelphia, Pa. Mr. Jenkins has been with Westinghouse since 1940, when he joined the company's graduate student training course following his graduation from the University of Utah at Salt Lake City. He has held numerous engineering posts with the company in Pittsburgh, Pa., and Los Angeles, Calif.

J. C. Michalowicz (AM '41, M '47), associate professor of electrical engineering, Catholic University of America, Washington, D. C., has been named acting head of the department. He received his bachelor of electrical engineering degree at Catholic University in 1940 and after 2 years with the Rural Electrification Administration became a teaching assistant at the university. He received his master's degree in 1950.

Glen Ramsey (M '43), manager, Rectifier Division, Fansteel Metallurgical Corporation, North Chicago, Ill., has been elected vice-president of the company. He joined Fansteel as a research engineer in 1936. He became rectifier sales engineer in 1939 and in 1942 was made sales manager of the rectifier division. In January 1952 a rectifier-capacitor division was created with Mr. Ramsey as general manager. He has served the AIEE on the Committee on Metallic Rectifiers (1949–52).

E. L. Anderson (M '48), electrical superintendent, Bethlehem Steel Company, Johnstown, Pa., has been elected first vice-president of the Association of Iron and Steel Engineers.

G. M. Nelson (AM '50), vice-president and general manager, Eastern Shore Public Service Company, Salisbury, Md., has been named president of Eastern Shore Public Service Company of Maryland and Eastern Shore Public Service Company of Virginia. He began his engineering career with the Pennsylvania Railroad and later joined the engineering department of Philadelphia Electric Company. He started with Eastern Shore Public Service in 1926 as right-of-way agent. Two years later he was promoted to assistant superintendent of operations and in 1935 became superintendent. In 1946 he was made vice-president and general manager.

A. C. Allen (AM '40), branch manager, Wagner Electric Corporation, Memphis, Tenn., has been appointed sales manager of the Electrical Division. Mr. Allen began his career with the Wagner company in 1930 immediately after graduating with a bachelor of science degree in general engineering from the University of Illinois. After student engineering training with the company, he entered the sales department and later became a salesman at the St. Louis (Mo.) sales office. In 1935 he was transferred to Memphis where he ultimately became manager of the electrical sales branch.

A. W. Fraps (AM '42), manager, construction department, Koontz Engineering and Electric Company, Inc., South Bend, Ind., has been named central station sales manager, Roller-Smith Corporation, Bethlehem, Pa. He received his bachelor of science degree in electrical engineering from the University of Arizona in 1931 and a master of science degree from the California Institute of Technology in 1932. That year he joined the General Electric Company in Schenectady, N. Y., and in 1936 transferred to the Switchgear Department in Philadelphia, Pa.

A. A. Jones (M '46, F '51), manager, Engineering Department, Anaconda Wire and Cable Company, Hastings-on-Hudson, N. Y., has been re-elected to the post of secretary of the New York District Council of the American Society for Testing Metals. Mr. Jones has served the AIEE on the Transmission and Distribution Committee (1948–49).

OBITUARY

Warren Dunham Hardaway

Warren Dunham Hardaway (AM '22, M '32, F '51), superintendent, Hydroelectric Production and Transmission, Public Service Company of Colorado, Denver, died on October 27, 1952. Mr. Hardaway was born in Ord, Nebr., August 17, 1896, and was graduated from Iowa State College in 1919 with a bachelor of science degree in electrical engineering. He entered the employ of the Denver Gas and Electric Company, the predecessor of Public Service Company of Colorado, on July 3, 1919. He was a member of The American Society of Mechanical Engineers and Tau Beta Pi, and was a registered professional engineer in Colorado. He had been an active member of the AIEE, serving as vice-chairman of the Denver Section in 1931 and chairman in 1932. He had served on the following Institute committees: Power Generation (1938–47); Switchgear (1947–51); System Engineering (1947–50); and Protective Devices (1949–53).

H. F. E. Schuster, Jr. (M '44), manager, Electronics and Functional Test Planning Department, Lockheed Aircraft Corporation, Marietta, Ga., died August 7, 1952. Mr. Schuster was born in Savannah, Ga., September 5, 1909, and received his bachelor of science degree in electrical engineering from the University of Georgia in 1933. From 1933 to 1940 he was employed by the United States Forest Service. During World War II he was employed by the United States Army Signal Corps as electrical engineer on design and construction of telephone systems at Army posts and later by the Bell Aircraft Corporation as electrical engineer responsible for correct installation and operation of the electrical system on *B-29* airplanes. After the war he was associated with the United States District Engineers office in Savannah. Mr. Schuster was a registered professional engineer, a member of the Georgia Society of Professional Engineers, Society of American Military Engineers, and Phi Kappa Phi. He was a former member of the executive committee of the AIEE Savannah Subsection.

Donald Gunn (M '36), vice-president, Pennsylvania Water and Power Company, and assistant advisory engineer, Safe Harbor Water Power Corporation, Baltimore, Md., died on October 22, 1952. Mr. Gunn was born in Rome, Ga., December 3, 1902, and was graduated from the Georgia School of Technology in 1925 with a degree of bachelor of science in electrical engineering. Following his graduation, Mr. Gunn joined the staff of the Byllesby Engineering and Management Corporation in Pittsburgh, Pa., and was later employed by the Duquesne Light Company. He joined the Safe Harbor Water Power Corporation as budget engineer in October 1930. He received successive promotions and became vice-president and chief engineer of Pennsylvania Water and Power Company, sister company of the Safe Harbor Corporation, on June 1, 1947. Mr. Gunn was a member of the American Society of Civil Engineers.

MEMBERSHIP

Recommended for Transfer

The Board of Examiners at its meeting of November 20, 1952, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Albrecht, F., electronic tooling chief, The Glenn L. Martin Co., Baltimore, Md.
Antrim, M. B., electrical maintenance supt., Lukens Steel Co., Coatesville, Pa.
Bourne, R. D., asst. professor of electrical engg., Vanderbilt University, Nashville, Tenn.
Briggs, A. S., Jr., district supt., Philadelphia Electric Co., Penndel, Pa.
Coombs, J. C., electrical engineer, U. S. Corps of Engineers, Sacramento, Calif.
Cultum, G. L., electrical engineer, Bouillon & Griffith, Seattle, Wash
Davis, R. L., Jr., design engineer, General Electric Co., West Lynn, Mass.
Dreisbach, R. J., distribution engineer, Ohio Edison Co., Akron, Ohio
Everett, R. R., motor application engineer, Bodine Electric Co., Chicago, Ill.
Fini, A., assistant to meters & test supt., Niagara Mohawk Power Corp., Buffalo, N Y.
Frederick, J. J., electrical engineer, Gilbert Associates, Inc., Reading, Pa.
French, F. L., manager, electrical conductor div., Aluminum Co. of Canada, Ltd., Montreal, Quebec, Canada
Giusti, V. F., engineer, Hunter Fan & Ventilating Co., Memphis, Tenn.
Glinski, G., development director, Computing Devices of Canada, Ltd., Ottawa, Ontario, Canada
Kazda, L. F., asst. professor of electrical engg., University of Michigan, Ann Arbor, Mich.
Kelly, L. D., sales engineer, General Electric Co., Oakland, Calif.
King, J. H., assistant engineer, New England Power Service Co., Malden, Mass.
Koutnik, E. A., engineer, Commonwealth Services Inc., Jackson, Mich.
Kradel, F. L., electrical engineer, I-T-E Circuit Breaker Co., Greensburg, Pa
Lacy, E. E., manager, Butte Office, Westinghouse Electric Corp., Butte, Mont.
Liao, T. W., supervising engineer, General Electric Co., Pittsfield, Mass.
Lothes, R. N., instructor, electrical engg. dept., Syracuse Univ., East Syracuse, N. Y.
Martin, E. T., chief, central frequency staff, International Broadcasting Service, New York, N. Y.
Matson, W. E., engineer, General Electric Co., Schenectady, N. Y.
McCann, J. J., asst. engineer, Pacific Gas & Electric Co., San Francisco, Calif.
Meeks, H. W., manager, Jackson Electric Dept., Jackson, Tenn.
Nistico, F., research engineer, Celanese Corporation of America, Summit, N. J.
Paulaharju, L. J., electrical engineer, Canadian Westinghouse Co., Ltd., Hamilton, Ontario, Canada
Schwennesen, D. O., chief engineer, transformer div., Essex Wire Corp., Chicago, Ill.
Smith, J. A., supt. system operating div., The Shawinigan Water & Power Co., Montreal, Quebec, Canada
Taylor, A. B., engineer, General Electric Co., Schenectady, N. Y.
Terhune, R. S., sales manager, Nelson Electric Mfg. Co., Tulsa, Okla.
Trbovich, M., electrical engineer, Naval Research Laboratory, Washington, D. C.
Walter, G. E., section engineer, General Electric Co., Fort Wayne, Ind.

34 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should so notify the Secretary before January 25, 1953, or March 25, 1953, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Bibbero, R. J., Republic Aviation Corp., New York, N. Y.
Bricaud, J. M., Schlumberger Well Surveying Corp., Houston, Tex.
Graham, F. D., Wright-Patterson Air Force Base, Dayton, Ohio
Osterland, E., Edmund Osterland Co., Denville, N. J.

4 to grade of Member

Continuous Coal Mining System Developed to Handle Coal Removal in Outcrop Seams

A continuous coal mining system has been developed by Carbide and Carbon Chemicals Company designed for handling coal in outcrop seams by remote control. For this type of seam, preparation for coal removal is relatively simple. A working shelf is cleared at the level of the outcrop, and the mining rig takes over.

The mining rig is a self-propelled double-decked steel structure. On the first deck is a runway or launching platform for the mining machine. In the center of the runway is a coal conveyor. Adjacent to it is a control panel for moving the whole rig, and an enclosed cab that houses the remote controls for the mining machine. On the second deck are the cable reels for the power and control cables that guide the machine and electric switchgear.

This whole structure is mounted on four hydraulic jacks, which can be adjusted so that the launching platform is at the proper height for the mining machine to enter the seam. In order to move along the face of the seam, these jacks are raised enough to allow rails suspended from the undercarriage to be rolled out by an electrically driven winch. The jacks are let down until the rig rests on wheels on the rails and the four hydraulic jack pads are off the ground. Then the winch pulls the rig over to the next position. If the exposed face is irregular, the rails can be pivoted until the platform is at the correct angle. When the platform is in position, the hydraulic jacks are raised to support it at the proper height.

The mining machine is mounted on crawler tracks, which are driven by a variable-speed electric motor. Its "business end" consists of four overlapping cutting heads with cutting teeth that are tipped with tungsten carbide. The sections between the holes cut by these heads are shaved off by fixed cutter blades just slightly to the rear of the heads. Between them, the heads and the blades make a smooth, even hole about 10 feet wide and 3 feet high. Of course, by making successive cuts, the full height of the seam can be mined.

The continuous stream of coal flows from the rig conveyor to a short transfer conveyor, which feeds the elevating conveyor of the truck-loading hopper

Behind the outer cutting heads revolving on the same shaft are paddles that move the coal cuttings to the middle, where they are picked up by the central flight conveyor and carried from the front to the rear of the machine. From the fixed cutter blades back, the whole cutting end is encased in a metal shield, so that the coal can escape only by means of the machine conveyor.

Electric sensing devices called "Stratascopes" are mounted on the outermost cutting teeth of each of the outer two cutting heads. In the control cab, the Stratascopes are coupled to two polar oscilloscopes having circular screens somewhat like a radar screen. Each makes a circle of light to trace the paths of the two sensitive teeth. Every time the Stratascope teeth cut through anything harder than the normal coal in the seam, they cause irregularities, or "blips," in the light circles. They indicate which strata in the coal seam are being cut, and the relation of these strata to the center of the hole. (*See pictures and story page 17.*)

Since the strata in a coal seam bear a more or less fixed relation to each other and to the extremities of the seam, the oscilloscopes give the operator the information he needs to steer the machine on a predetermined course. Then, from his cab on the launching platform, the operator guides the machine up or down to follow the coal seam. He can correct any tendency the machine may have to "spiral," and steer it to make a straight hole, or to follow the adjacent hole at any desired distance.

To begin mining, the rig carrying the machine on its launching platform is located at the proper angle and height. If the launching platform does not abut the seam face, the gap is bridged by extending two telescoped sections of the runway. The operator starts the cutting heads and conveying system, and then moves the machine ahead on its crawler tracks. First, the pilot drill taps the coal and starts sinking the pilot boring. In a few moments, the main cutting heads reach the seam and begin to bite. They crack the coal into small pieces that are pushed by the paddles and carried up through the middle of the machine on the conveyor.

At the rear of the machine, the coal falls from the central flight conveyor to the conveyor in the launching platform. The continuous stream of coal flows along the rig conveyor to a short transfer conveyor, which feeds the elevating conveyor of the truck-loading hopper. From this point, it travels by 20-ton trucks to the hopper at the let-down conveyor to the storage pile.

When the mining machine is almost underground, the rear of its central flight conveyor reaches the end of the platform conveyor. At this point, the machine is stopped and a portable conveyor is added. Each of these conveyors is about 30 feet long and is mounted on two pneumatic tires located at the rear end. The front end of the portable conveyor is attached to the mining machine, which now will both mine the coal and haul the train of conveyors. At the rear of the conveyor, the cable is plugged in to supply power for the motor that drives the belt. To prevent fouling or dragging the mining machine power cables, each conveyor has large L-shaped hooks on its side for carrying them as they come down from the reels on the second deck of the rig.

As each portable conveyor reaches the end of the platform conveyor, another is added. Actually, this operation takes only a couple of minutes, because the conveyors are brought in overhead by a tractor-mounted crane that suspends each portable conveyor just above the rig conveyor until it is needed. The number of conveyors added depends on the depth of the hole being bored.

When the machine has bored as deeply as desired, the electric motors are reversed and the machine pushes instead of pulls its train of portable conveyors. The train is unhitched the same as it was assembled. Finally, the machine itself backs out into the daylight on the launching platform. This part of the operation is much quicker, since the machine can be backed at 30 feet a minute.

If the thickness of the seam warrants, the four hydraulic jacks are let down until

Future Meetings of Other Societies

American Management Association. General Management Conference. January 12–15, 1953, Hotel Statler, Los Angeles, Calif.

American Society of Heating and Ventilating Engineers. 59th Annual Meeting. January 26–29, 1953, Conrad Hilton Hotel, Chicago, Ill.

Compressed Air and Gas Institute. January 14–16, 1953, Dayton Biltmore Hotel, Dayton, Ohio

Heat Exchange Institute. January 26–28, 1953, Seaview Country Club, Absecon, N. J.

Hydraulic Institute. January 19–21, 1953, The Homestead, Hot Springs, Va.

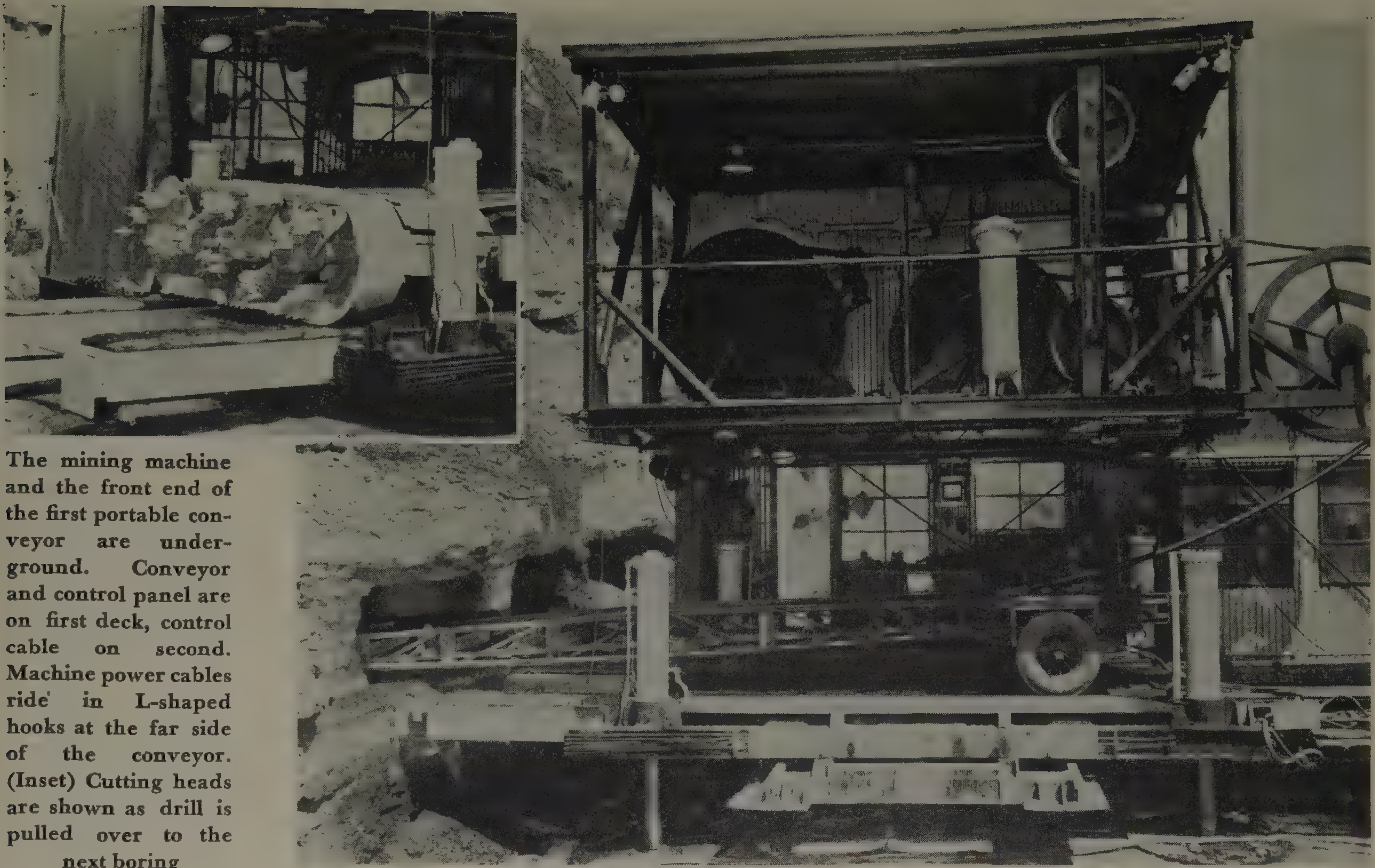
Institute of Radio Engineers. Southwestern Conference and Electronics Show. February 5–7, 1953, Plaza Hotel, San Antonio, Tex.

Midwest Research Institute. Symposium on Automatic Computing Equipment. January 8–9, 1953, Kansas City, Mo.

National Association of Corrosion Engineers. 5-day, Short Course in Corrosion. February 2–6, 1953, University of California, Berkeley, Calif.

Plant Maintenance Conference. January 19–22, 1953, Public Auditorium, Cleveland, Ohio

Society of Plastics Engineers. 9th Annual Technical Conference. January 21–23, 1953, Hotel Statler, Boston, Mass.



The mining machine and the front end of the first portable conveyor are underground. Conveyor and control panel are on first deck, control cable on second. Machine power cables ride in L-shaped hooks at the far side of the conveyor. (Inset) Cutting heads are shown as drill is pulled over to the next boring

the platform is in position to make a second cut below the first. When the seam is not thick enough to permit a full 3-foot bite on the second boring, the coal is kept flowing at the same rate by increasing the forward speed of the machine.

When the second cut has reached the depth of the first, the process is once again reversed to remove the conveyors and the machine. With the mining machine on the launching platform, the rig is moved over on its rails so that there will be a wall about 3 feet thick between the boring just made and the one to be started. In about 20 minutes, the mining machine is ready to take over again.

When this project was first started, the depth of the holes was limited to 560 feet by the length of power cable. Since then, the cable has been increased to 1,000 feet. Right now, the machine is boring 700-foot holes, which is the sum total of the portable conveyors on hand. However, it is expected that this machine could make these 3- by 10-foot holes for over 1,000 feet into the hillside.

Variations in the coal face at the outcrop and variations in the seam can dictate the use of different cutting patterns. Sometimes faults in the seam, such as pinching out, limit the depth of boring.

The operators of this machine are always above ground, and they have little or no actual contact with coal. Yet the underground machine they control sends out by way of conveyors up to $1^2/_3$ tons of coal a minute. The size of this coal ranges up to 4 inches, and the percentage of fines is not materially different from other coal mined mechanically.

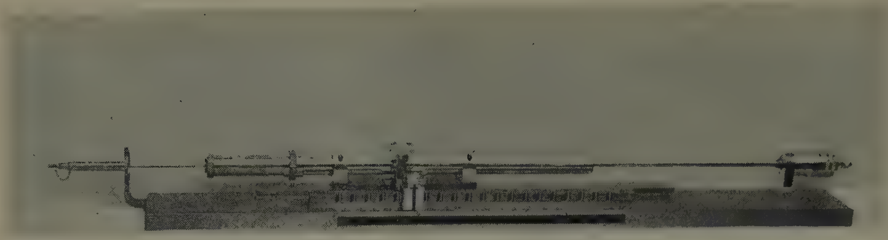
Permeability of Magnetic Materials Tested by High-Frequency Calibration

The National Bureau of Standards (NBS) recently established a calibration service for determining the radio-frequency permeability and loss factor of magnetic materials in the frequency range between 50 kc and 30 megacycles. The primary calibrating standard is a coaxial line of variable length constructed to dimensions of extremely high accuracy. The characteristics of magnetic materials, such as the ferrites and powdered irons, are determined in terms of the variation in the length of the line. The Bureau also has developed a secondary standard of calibration that may be simply reproduced and utilized in the manufacture of magnetic materials.

The increased use of magnetic materials in high-frequency electronic equipment has resulted in a need for more accurate evaluation of their behavior at the elevated frequencies. Ferrites and powdered irons have contributed to the reduction in size of electronic components. These materials have been modified to perform such functions as magnetic memories and amplifiers, attenuators, filters, and loop antennas for small radio receivers. In some applications, the losses in the material are of little importance, in others, high losses are actually used to advantage; however, in most instances, it is desirable to use a material with high permeability and low loss factor.

To evaluate the characteristics of magnetic materials, experiments have been conducted on thousands of compositions, with a variety of results. Little difficulty is encountered in determining the d-c characteristics of the materials; these experiments are performed with comparative ease and accuracy and yield valuable information. However, the procedures are not valid for determining the behavior of ferrites and powdered irons at high frequencies. These high-frequency characteristics are best described by the radio-frequency permeability and loss factor (complex permeability) of the magnetic materials. The determination of these factors, besides being of interest to the designer and engineer, is important to the manufacturer of magnetic materials, who must use this knowledge as a basis for the quality-control phase of the manufacturing process.

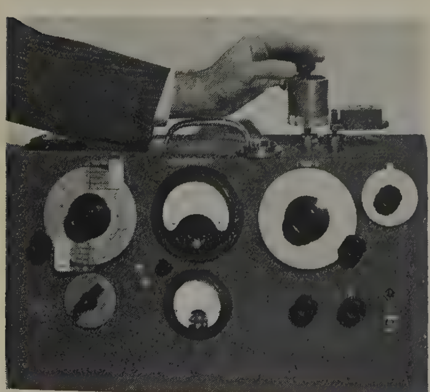
The NBS primary standard of radio-frequency permeability and loss factor was designed by P. H. Haas of the Bureau's high-frequency standards laboratory. The method of measurement depends on the change in inductance of an accurately machined coaxial line when a sample of magnetic material is inserted. The variable-length coaxial line is accurately calibrated in 19 1-inch stops and includes a micrometer system that permits the measurement of variations to within 0.0005 inch along the 20-inch range. All machining tolerances were held to ± 0.0002 inch. The line is made completely from nonmagnetic materials to reduce the possibility of extraneous magnetic fields affecting the measurement.



NBS primary standard for determining the radio-frequency permeability of magnetic materials. The standard is a variable-length coaxial line, accurately calibrated in 19 1-inch stops. A micrometer system (right) permits the measurement of variations to within 0.0005 inch along the 20-inch range. The magnetic material to be tested is ground into the shape of a coaxial disk and is inserted into the line at the left. A radio-frequency bridge, connected to the variable length line, is balanced with no sample in the line and rebalanced after the sample is placed in the line

In a typical investigation, a sample of magnetic material is ground into the shape of a coaxial disk that completely fills a section of the space between the conductors of the coaxial line. In the grinding process, all tolerances are ±0.0002 inch. The output terminal of the coaxial line is connected to the "unknown" terminal of radio-frequency bridge suitable for measuring inductance in the frequency range at which the material will be used. First, the bridge is balanced with no sample in the line and the coaxial segment extended to almost its full length. The disk of magnetic material is then placed on the center conductor of the line. A metal cap holding the disk in place short-circuits the end of the coaxial line. The resulting bridge unbalance is adjusted to the original conditions by a combined manipulation of the resistance reading arm on the bridge and a reduction in the length of the line. The variation in length is directly proportional to the permeability of the magnetic material relative to air and constitutes a primary method of measurement. The difference in resistance readings is a measure of the loss factor of the material and is limited only by the inherent accuracy of the bridge instrument.

The use of such highly precise and delicate calibration equipment as part of a production line, however, is restricted by the rigors of the manufacturing process. The method more commonly used in routine measurements employs a toroidally shaped ring upon which a number of windings have been placed. Quality control is achieved by comparing representative products with this standard. The major disadvantage of this method, aside from the necessity of winding a large number of turns on each toroid to be tested, is the poor accuracy resulting from shunting capacitances and displacement currents, especially in the case of materials with high dielectric constants. Thus, a device has been needed that would give a reasonably accurate indication of the degree of variation of the finished product with respect to the standard. The secondary standard of calibration developed by NBS is designed to yield the necessary information and is rugged enough to become an integral part of the production line. Its accuracy is limited only by the precision of the bridge instrument used in the calibration.



Radio-frequency permeameter is the secondary standard for the measurement of permeability and loss factor of magnetic materials. The principle of operation depends on the change in input impedance reflected into the primary of a transformer by load variations in the secondary

The radio-frequency permeameter, as the secondary standard is called, is a modification of an instrument described by G. A. Kelsall,[1] for the measurement of permeability alone at low audio and power frequencies. The principle of operation depends on the change in input impedance reflected into the primary of a transformer by load variations in the secondary. The transformer of the NBS permeameter is composed of a reference toroid and a length of coaxial line; changes in the secondary are produced by the insertion of a toroid of magnetic material into the coaxial line.

The NBS radio-frequency permeameter, also developed by P. H. Haas, is machined from a 2-inch brass rod into a cylinder with an inner diameter of $1^1/_2$ inches and a length of about $1^3/_4$ inches. Both ends of the line are fitted with short-circuiting covers. The top cover is readily removable to admit the sample materials. It was made of beryllium copper so that the bearing surfaces could be machined into a springy yet electrically tight fit. The bottom cover is attached to the cylinder by screws and has a central spike, $^3/_{16}$ inch in diameter, which forms the center conductor of the coaxial line. A hole is tapped into this cover to receive a type-*N* cable plug. A shelf made of low-loss insulating material separates the upper third of the cylinder from the lower portion.

The coaxial line is designed to receive toroidal rings with inner diameters greater than $^3/_{16}$ inch, and outer diameters less than or equal to $1^1/_2$ inches. A wall thickness of $^1/_4$ inch was chosen to improve the high-frequency shielding and to give ample mechanical strength. The shelf acts as a holder for the material to be tested.

A toroidal ring is slipped over the center conductor and rests on the bottom cover of the coaxial line. A number of windings, suited to the conditions of the experiment, are wound on the toroid. The material of the toroid has a low dielectric constant and a high Q at the frequency to be used during the test. One end of the winding is connected to the type-*N* cable plug, and the other end to the coaxial line, thus making the system electrically unbalanced. In this position, the toroid acts as a reference for the measurement by becoming the primary of a transformer, the secondary of which is the metallic portion of the coaxial line.

A connection is made between the type-*N* cable plug and a radio-frequency bridge or a Q-meter. The bridge is first balanced with the secondary of the transformer unloaded. The magnetic material to be tested (formed into a toroid and without windings) is then placed on the shelf in the line, and the impedance bridge is rebalanced. The variation in input impedance, as read on the bridge, is the quantity from which the permeability and loss factor of the test ferrite or powdered iron are computed.[1]

A simple adaptation of the radio-frequency permeameter has been made to allow the measurement of the temperature coefficient of magnetic materials. This property is important in most military applications of ferrites and powdered irons and in devices depending on elevated temperatures as a means of insuring high stability.

REFERENCE

1. Permeameter for Alternating Current Measurements at Small Magnetizing Forces, **G. A. Kelsall.** *Journal, Optical Society of America and Review of Scientific Instruments* (New York, N. Y.), volume 8, number 2, February 1924, pages 329–38.

AAAS Holds Annual Meeting in St. Louis, December 26–31

The 119th annual meeting of the American Association for the Advancement of Science (AAAS) was held in St. Louis, Mo., December 26–31, 1952, as a part of Washington University's Centenary and the final event of the Centennial of Engineering. The general topic for the meeting was "The Contribution of Science and Mathematics to Engineering and Industry."

The AAAS Presidential Address by Kirtley F. Mather, retiring president of the association, and the reception were given on December 28.

There were two general symposiums. The first consisted of sessions on "Disaster Recovery—The Common Principles and Best Measures," embracing floods, earthquakes, tornadoes and hurricanes, industrial disasters, fire raids, atomic blasts. Aspects discussed were emergency measures, health measures, law and order, psychology, transport, communications, public information, legal aspects, plant rebuilding or relocation, and city planning.

The second symposium was on "The Nation's Nutrition: From Soil to Cytoplasm."

The sectional programs included sessions in the following fields: mathematics,

physics, chemistry, astronomy, geology and geography, zoological and botanical sciences, anthropology, psychology, social and economic sciences, history and philosophy of science, engineering, medical sciences, medicine, dentistry, pharmacy, agriculture, industrial science, education, and science in general.

Awards and grants which are administered by AAAS were announced at the meeting.

Sessions of the engineering section included programs on scientific manpower, men and machines, nuclear science in industry, methodology in engineering research, and effective utilization of industrial manpower.

IEC Discusses Agreement on Electrical Standards

Nineteen countries were represented by 418 delegates at a series of meetings of the International Electrotechnical Commission (IEC) at Scheveningen, Holland, in September 1952 to discuss international agreement on electrical standards. The United States, represented by 14 delegates, participated in almost all of the technical meetings.

Among important actions taken this year at the IEC meetings was authorization of a new technical committee to develop standards for electronic tubes. This work has heretofore been part of the duties of the Technical Committee on Radio. Organization of the new committee recognizes the fact that the use of electronic tubes has now extended into a much broader field than radio alone. This follows the development of standardization in the United States. Holland was assigned the secretariat for the new committee.

A number of standards were completed and will be submitted to the national committees for approval. These included revision of the specifications on rotating electric machinery; preferred standards for 50-cycle turbines and for 3,000-rpm 3-phase 50-cycle turbine-type generators; a basic list of graphical symbols; a revised list of standard voltages; power losses and methods of expressing efficiency of electric equipment; safety rules for amplifiers and loudspeakers; several standards for radio components; temperature rise for circuit breakers, normal loading conditions; a revision of standards for power capacitors; dimensions of electronic tube bases and tube gauges; and two specifications for high-voltage insulators.

The IEC Council, the Commission's governing body, and the Committee of Action, its executive committee, considered strengthening co-operative relations between IEC and other international organizations. Arrangements were made for extending co-operative action on standards of joint interest to IEC and the International Commission on Rules for the Approval of Electrical Equipment (CEE). This is a European organization developing safety rules for radio receivers, loudspeakers, amplifiers, television receivers, household appliances, wiring devices, and similar equipment. It is now extending its activities into other fields closely related to those covered by IEC. The rules adopted by CEE are used by European governments in inspection and approval of electric equipment.

Closer co-ordination of IEC work with that of the International Organization for Standardization was also discussed.

A request from the Organization for European Economic Co-operation (OEEC) for the fastest possible progress on projects which OEEC believes would help in stimulating international trade was given serious consideration. These are in the field of light electric equipment, including domestic appliances for room heating and cooking, protective devices for motors, medical appliances and X-ray apparatus for medical use, arc welding apparatus, measuring instruments, radio receivers, and interference suppression devices. In most cases there are now differences in standards used by different countries for these types of equipment. The request is being passed along to the secretariats for the projects in question and arrangements are being made for close liaison with OEEC in the future.

Suggestions for new work considered by the Committee of Action included expansion of the project on graphical symbols and increased activity on switchgear to include contractors, starters, bus bars, switchgear assemblies, and the like, both for low and high voltages, except for domestic installations. Work on electro-acoustics was revitalized and the secretariat of the technical committee transferred from the British National Committee to the Netherlands Electrotechnical Committee.

Accepting an invitation from the Yugoslav National Committee, the IEC decided to hold its 1953 meeting at Opatija on the Istrian Peninsula. These meetings will be scheduled for two weeks beginning June 22. The 1954 meetings will be in the United States to celebrate the Commission's 50th anniversary.

Giant Safe Protects Nation's Priceless Documents

Three of the United States' most priceless documents will soon be put to bed every night in the world's largest safe, it was revealed recently by the Mosler Safe Company.

Containing the most advanced safety features known to science, the unique safe will safeguard the irreplaceable original copies of the Bill of Rights, Declaration of Independence, and the Constitution of the United States.

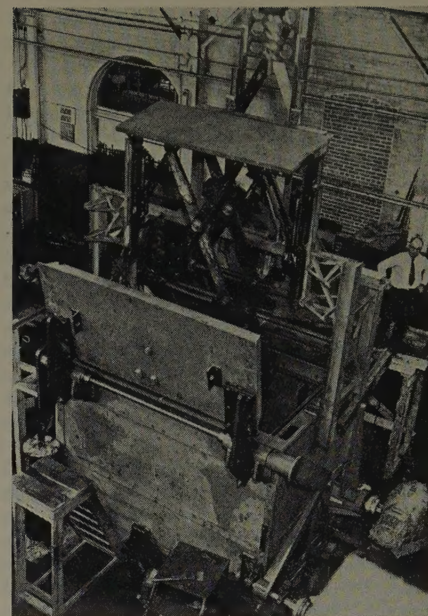
The giant safe, only one of its kind, will have a built-in elevator which will raise the documents every morning and lower them back into the safe every night. To make this possible, the unit's massive doors will be located on the top of the safe.

The safe will be bomb, fire, burglary, and water-resistant, according to Mosler engineers who have been working on the unusual project. The world's largest safe, it will weigh 50 tons.

It is now being installed far beneath a remodeled display shrine in the National Archives building in Washington, D. C.

During the day, visitors will be able to inspect the three priceless original documents which will be displayed in a large glass showcase on the shrine.

After visiting hours, the entire showcase with its contents will be lowered by a scissor-like elevator deep down into the hidden safe. The safe's huge 5-ton steel doors will automatically swing shut and lock as soon as the descending documents enter the giant safe.



A scissor-type built-in elevator is one of the unique features of the world's largest safe. Shown with elevator raised, the safe will raise the documents into a display shrine in the morning and automatically lower them back into the safe every night

Turbo-Pump Instantly Supplys Extra Fuel Required by Jet Engines

A new tank-mounted turbo-pump suitable for instantly supplying the extra supply of fuel which jet engines require for reheat operation has been announced by General Electric's Aircraft Gas Turbine Division.

Driven by high-pressure air from the jet engine's compressor, the pump combines boost, high-pressure, and vapor-separator elements in one package to replace the heavier and more complex line-mounted pump and electrically driven booster-pump combination.

The new pump is designed around the dual-rotor system which involves two separate turbine wheels which have no mechanical interconnection. One turbine drives the vapor separator and the low-pressure boost pump, and the other turbine drives the high-pressure pump element.

One of the outstanding features of the new pump is that there is no mechanical connection with the engine. Only a pneumatic connection is needed, thus leaving an engine-driven gear pad available for other service.

The simplicity of the design makes it unnecessary for the pilot to give the pump any attention. It is turned on or off automatically whenever the afterburner is needed. Unlike a gear-driven pump, the new turbo-pump can be turned on and off while the engine is operating. This eliminates the recirculation of fuel with its accompanying energy loss and resultant undesirable fuel heating during main engine

operation without afterburning. Also, this intermittent operating feature reduces the frequency of overhaul.

Vapor separation in the new pump is achieved effectively by a new method of vapor elimination supplied by Nash Engineering Company. This element permits the pumping of high-vapor-pressure fuels throughout the range of altitude and climb rates required by our latest designed aircraft. The pump delivers approximately 86 gallons of fuel per minute at a pressure rise of 510 pounds per square inch.

Only the necessary air connections protrude below the tank as the major portions of the unit are completely immersed in the fuel. Since the pump is mounted inside the tank, no boost is required at the pump fuel inlet.

All necessary cooling is accomplished internally by both fuel and air. The air is drawn into double-walled sections of the pump by a built-in ejector, thus eliminating the need for ram air. The fuel itself provides the necessary lubrication. When all the fuel is consumed, an aerodynamic overspeed control prevents pump damage until the pump is turned off.

United Nations Begins Program to Promote Rural Electrification

Over 30 specialists from 12 western European countries, Costa Rica, India, and the United States have begun in Geneva, Switzerland, an ambitious United Nations effort to promote rural electrification in all parts of the world.

Their plan is to exchange ideas and to apply experience, particularly that of Europe, so that costly errors in rural electrification may be avoided and proved successful methods may be applied more speedily.

The aims of the program are these: (1) to raise the productivity of the huge proportion of humanity engaged in agriculture, and to improve living standards in general; (2) to bring to farmers the assistance and advantages which electricity can provide; (3) to effect savings in rural electrification costs; and (4) to increase trade and contribute to the full utilization and expansion of industries producing electric equipment.

A consciousness of the contribution which rural electrification could make to the realization of these important goals has led governments, United Nations organs, and various industries and professions to their present co-operation in this field. The idea for this effort was first proposed by Yugoslavia at a United Nations Economic Commission for Europe (ECE) session in Geneva in 1950.

Responsibility for practical work was passed to ECE's Committee on Electric Power. The committee in turn worked out a program in which it sought the help of the Food and Agriculture Organization and the United Nations Technical Assistance Administration, as well as that of various government ministries and through them that of important semipublic and private enterprises.

The pooling of resources for the efficient development of rural electrification is reflected in all phases of this United Nations program. The first phase was the ECE Power Committee's planning of a study whereby European countries could pass on to all countries, but particularly those less developed economically, hard-learned successful methods for the technically sound development of electricity production, transportation, and distribution; for effectively using electricity in rural areas; and for solving administrative and financial problems in this field. Fourteen European countries submitted monographs on these points.

These monographs reflected diversified experience in facing rural electrification's varied and complex problems as revealed in widely differing geographical areas and stages of economic development. They provided the basis for the second phase of the work. That phase is one of analysis and synthesis by four outstanding experts of the lessons learned. These experts come from France, Sweden, Switzerland, and the United Kingdom.

Their task is to prepare a comprehensive reference work of experience-proved best methods for electrifying various kinds of agricultural regions. They began this 2-months' task in Geneva on October 14, 1952. The United Nations Technical Assistance Administration and the Food and Agriculture Organization are financing this phase of the work, which is under the direction of ECE's Electric Power Section.

On October 27, 1952, rural electrification specialists from 15 countries in Europe, North and Latin America, and Asia began the third phase of the ECE program. They opened a 3-week seminar to present their problems of rural electrification and exchange ideas on best means of solving them.

This study group seeks the benefit of knowledge for immediate application, and it is expected to add a further element of pertinency to the study of the four experts. The practical problems and day-to-day experience of these engineers and economists from many regions especially highlight difficulties in countries which now are taking concrete measures to meet the demands of their people for substantially improved living conditions and which see electrification as one of those means. The give and take of oral ideas on specific points has been supplemented by exhibits, extensive technical documentation, and 15 films from five countries.

The four experts will continue after the seminar the preparation of their study on practical methods for rural electrification in the different parts of the world. Publication of the study early in 1953 will mark the fourth phase of the ECE Electric Power Committee's program. This is the final phase as planned by the committee to date.

Sites on Ohio River Selected for Largest Generating Stations

Sites on the Ohio River at Madison, Ind., and near Gallipolis, Ohio, have been selected for the world's two largest steam-electric generating stations.

Philip Sporn (F '30), president of the Ohio Valley Electric Corporation, recently formed by 15 electrical utilities of the Ohio Valley region, has announced that the corporation will proceed immediately to construct the two plants. They will supply the full electric power requirements of the Atomic Energy Commission's (AEC) billion-dollar uranium diffusion plant to be built near Portsmouth, Ohio.

Construction of the plant near Gallipolis will be handled by the Ohio Valley Electric Corporation, and of the Madison plant by the Indiana-Kentucky Electric Corporation, an Ohio Valley subsidiary. At peak of construction, 3,000 workers will be employed at the Madison station, and 2,400 at the Gallipolis project.

Combined capacity of the two plants will be 2,200,000 kw, of which 1,800,000 kw has been contracted for by the AEC for a 25-year period. This represents the largest single block of power ever supplied to a single customer in history of the electric power industry. The balance of capacity is considered necessary for attendant losses of power in transmission and for reserve capacity generally considered adequate for regular maintenance and overhaul. During abnormal emergencies the capacity will be further supplemented by about 200,000 kw from the sponsoring companies.

The Indiana plant will consist of six turbogenerating units of 200,000 kw each, or a total of 1,200,000 kw. The Ohio plant will have five units of the same capacity, or a total of 1,000,000 kw. Both stations will be larger than any steam-electric generating plant in operation in the world today.

The first 200,000-kw unit at the Indiana plant is scheduled to be in operation in little more than 2 years, in January 1955. Thereafter, a staggered schedule of completion dates for remainder of the individual units will bring all 11 of them on the lines at intervals up to June 1956, according to present plans.

When in full operation, the two power stations are expected to provide the AEC project a total of 15,000,000,000 kilowatt-hours annually. This enormous power requirement is roughly 25 per cent greater than the present consumption of New York City with its 8,000,000 people. It also is roughly two-thirds of the electric power consumption of the entire highly industrialized state of Ohio, which in 1951 totaled slightly more than $22^1/_2$-billion kilowatt-hours.

Electric power generated at the two stations will be delivered over 330,000-volt transmission lines to be constructed to the AEC project. At 330,000 volts the transmission network will equal the highest voltage now planned anywhere in the United States.

Present plans call for construction of four 330,000-volt double-circuits to the AEC project, two from each power plant. The two from the Indiana plant would be routed via a switching station to be built in the general area of Cincinnati. First of the four double-circuits is scheduled to be completed by August 1954, and all of them are due in operation by August 1955.

In addition to the direct super-high-voltage lines from the two power plants to the diffusion center, the supply of electric energy will be "backed up" by the existing integrated high-voltage electric transmission systems of the 15 participants in Ohio Valley Electric Corporation. Each company of this group is directly or indirectly interconnected with every other company in the group and all of them operate in parallel with other systems.

University of California to Hold Industrial Engineering Institute

The Fifth Annual Industrial Engineering Institute of the University of California will be held in Berkeley on January 30–31, 1953, and in Los Angeles on February 2–3, 1953.

The purposes of this annual conference, according to D. G. Malcolm, General Chairman of the Institute, are to present fundamentals and important practical developments in the field of industrial engineering and management to the managers and engineers in attendance and to present results of industrial engineering research performed throughout the country.

The conference will include sessions on the following topics: industrial engineering in small- and medium-sized businesses; organization of the industrial engineering function; job evaluation and wage incentives; human problems in industrial engineering; and industrial engineering research.

Printed proceedings of the conference will be distributed to those in attendance.

Further information may be obtained from the Department of Conferences and Special Activities, University Extension, University of California, Los Angeles 24 *or* Berkeley 4.

New High-Altitude Suit Developed for Flying Personnel

The development of a new-type pressure suit, enabling pilots to survive in the near vacuum of the upper atmosphere, was announced recently by the United States Air Force. Called a *T-1*, High-Altitude Suit, it is the latest achievement of medical specialists of the Air Research and Development Command's Wright Air Development Center, Dayton, Ohio.

At altitudes above 40,000 feet pure oxygen alone is not sufficient to maintain a man in the healthy, efficient state, because, though pure, its pressure is too low. It is practical to supercharge the lungs with oxygen, forcing the flyer to breathe against built-up mask pressure; but this process gets more and more difficult as the flyer goes to higher altitudes, and ever-increasing supercharging pressures must be used. Between 45,000 and 50,000 feet, the amount of oxygen pressure which must be pushed into the mask and lungs to keep the flyer alive is so great that secondary troubles are created. Circulation through the lungs and heart is interfered with, and forcing the breath out against the pressure becomes extremely fatiguing.

Even if these difficulties could be overcome, at higher altitudes new problems arise. Above 63,000 feet, water will boil at man's normal body temperature; and since the body is 65 to 75 per cent water, when a human being goes above that altitude he can expect steam and vapor to begin forming rapidly inside him. In the blood stream this produces large bubbles which block circulation. In the tissues and body cavities, so much "steam" can form that the body, especially the trunk, may expand to twice its normal size. Death at these altitudes results in a matter of seconds.

Doctors, engineers, and technicians of the Aeromedical Laboratory had to solve this problem before progress could be made in developing the jet and rocket aircraft of the future required for this nation's security. It took these men 6 years to perfect the suit and helmet to do the job.

Preliminary work on the pressure suit originated in 1943 when a small group at the University of Southern California, under the direction of Dr. J. P. Henry, investigated the physiology involved. In 1946 the University of Southern California delivered its prototype suit to the Aeromedical Laboratory. Dr. Henry joined the Aeromedical Laboratory staff at this time and the Air Force began its intensive development of the suit.

In developing this suit, the project was complicated by the human factor of the varying sizes and shapes of flying personnel. The suit not only had to overcome such physiological problems, but also had to be an item which could be mass-produced.

The suit is worn uninflated and inflates automatically when cabin pressurization is lost. The inflated suit and helmet supercharge the flyer's lungs with high-pressure breathing oxygen and combine a new and unique method of applying counter pressure to the body's surface, thus protecting the flyer from collapse and making safe operation of the aircraft possible. Loss of cabin pressure could result, for example, from enemy action or materiel failure.

This radically new pressure suit follows no known pattern set by any other country, nor does it resemble earlier cumbersome suits developed during the past 20 years by various laboratories. Previous attempts at pressure suits resulted in hot and heavy equipment which gave the pilot little mobility.

The *T-1* resembles to some extent the popular conception of a space suit. It combines altitude protection with anti-G suit, crash helmet, oxygen mask, earphones, microphone, goggles and defroster, and oxygen bailout bottle.

Electrical-Optical Brain Gives Aircraft Rate of Descent Data

An electrical-optical "brain" developed by North American Aviation to give instant data on how fast an airplane "hits the deck" or lands, has won its sea legs in operational tests aboard the United States Navy's aircraft carrier *Midway*.

In the past the rate of descent for an experimental airplane has been recorded by cameras, but the photographed data were not available for several days. The instrument, Touchdown Rate of Descent Indicator (TRODI), flashes this information immediately.

All new Navy airplanes must be tested for rate of descent before they are placed in regular operation. Formerly in carrier landings, with an experimental airplane, a pilot would not know for some time if he had come in for a landing at the correct rate of descent. With TRODI's rapid brain, the data are ready for the pilot as soon as he steps from the cockpit. He then can correct his future landings if necessary.

A vital part of recent carrier suitability tests aboard the *Midway* for new Navy fighters, the new instrument recorded in a few landings results that would have required a number of days with the old camera method.

TRODI measures rate of descent with an accuracy of 0.4 foot per second and is in regular service with the Navy. The instrument also has applications to benefit other branches of the military services and civil aviation.

Portable, easy-to-handle, the instrument measures the rate of descent that aircraft structures can withstand, helps evaluate landing characteristics of airplanes controlled by automatic or manual systems, helps instructors teach student pilots skillful and safe landings, and aids in determining landing conditions suitable for various aircraft.

To seek rate of descent data, TRODI sends out two parallel beams of light, thin vertically and wide horizontally. They are 1 foot apart. A mirror system on the incoming airplane cuts the top beam, reflecting the light back to a photoelectric cell, which starts an electric charge into a capacitor. The descending airplane then cuts the second and lower beam, reflects it, and stops the charge going into the capacitor.

The electric charge stored during the interval between beams is quickly translated by TRODI from voltage to rate of descent in feet per second.

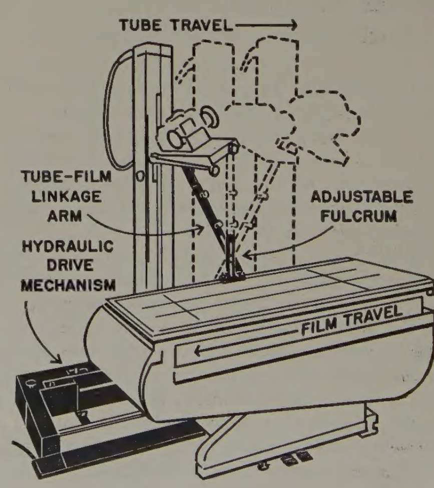
Ordograph Provides Film Quality for Body Section Radiography

The Ordograph, perfected recently by the General Electric Company X-Ray Department, provides a high X-ray film quality hitherto unobtainable and has aroused renewed interest in body section radiography, according to users' reports.

The Ordograph may be used for body section radiography with the patient in either the horizontal or vertical position, and may be adapted to use with several types and models of X-ray equipment.

According to users, the Ordograph has provided a hitherto unobtainable uniformity of motion, and provides controls which are continuously variable over a wide range of speed and tube travel.

The uniformity of motion and quality of image are made possible by the Ordo-



Principle of body section radiography

graph because of the smooth, positive action of the hydraulic-drive mechanism. Any thickness of body structure can be demonstrated by this technic, within the limits of the apparatus. However, a thin section will of course show better detail than a thick one.

In body section radiography, unlike regular radiography, motion is required in order to blur all body tissues except the precise layer which is under examination. The Ordograph causes the X-ray film and the X-ray tube to move in opposite directions during exposure, thus revealing only those areas of the body lying within the plane along which the axis of motion pivots.

This frequently permits the physician to see areas otherwise hidden by intervening body structures, or to visualize more clearly those which would be partially obscured.

Multiple-Exposure Film Holder Developed for Electron Microscope

A new multiple-exposure cassette or film holder makes it possible to record 20 micrographs on 35-millimeter film in an electron microscope without breaking the vacuum.

The new attachment for the Type *EMT* table model electron microscope made by Radio Corporation of America is designed for making wider area micrographs and makes it possible to obtain multiple exposures, at the same or different focal lengths without changing film. Twenty pictures of the same or different subjects may be taken without breaking vacuum in the instrument.

The new cassette is loaded in a dark room, then attached to the microscope in full daylight. It uses positive 35-millimeter film rolls or microfilm. The cassette clamps into place on the bottom of the microscope, in place of the plate holder formerly used.

The improved table microscope, Type *EMT-3*, incorporates two new features permitting more simplified operation. They are an external alignment for the pole piece and a new type of vacuum gauge. The former allows very precise alignment of the specimen in the instrument, and the new vacuum gauge provides a positive indication when the equipment is ready for operation.

French Electronics Industry Studies American Developments

To assist the French electronics industry to modernize its methods and designs in order to meet growing defense requirements, a 12-man team of management and technical representatives from France has come to the United States to study the latest American developments in this field.

The study is sponsored by the Mutual Security Agency (MSA) under its productivity and technical assistance program.

The French group is interested in United States production of commercial telecommunications equipment and radio and television receiving equipment, including spare parts and tubes. Also included will be studies of electronics applications in industry, such as servomechanisms and high-frequency heating. In addition to the technical aspects of the electronics industry, the group will also examine marketing; product development and research; production organization; and the effect on productivity of the quality of raw materials, working conditions, and capital equipment.

This is the sixth technical assistance team from the French electric equipment industry to make a study in the United States under sponsorship of MSA and its predecessor agency, the Economic Co-operation Administration. Since 1949, French teams have investigated American methods for the production of heavy electric machinery, small electric equipment, insulated wire and cable, electric domestic appliances, and industrial electric equipment such as motors and transformers.

IEE Invites Suggestions for Wiring Regulations Revision

The Institution of Electrical Engineers (IEE), London, England, is drafting a 13th edition of the Regulations for the Electrical Equipment of Buildings and is inviting comments putting forward proposed amendments from interested persons and bodies.

The current edition of the Regulations is the 12th, issued in May 1950. An abridged version relating solely to single-family dwellings using single-phase supply was issued in November 1951.

Comments should relate to the 12th edition of the Regulations only; the abridged regulations will be revised automatically to accord with the relevant parts of the text of the 13th edition when this is issued.

Comments should be addressed to the Secretary, The Institution of Electrical Engineers, Savoy Place, London, W. C. 2, England. They should reach the Secretary not later than January 1, 1953. Comments received after that date will be considered only if time permits.

The 13th edition of the Regulations is not expected to be issued before December 31, 1953.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Servomechanism Design

To the Editor:

I regret that the purpose of my recent article discussing "Linear Circuit Theory and Servomechanism Design" (*EE, Jul '52, pp 614–15*) was misunderstood by A. M. Fuchs, as is indicated in his recent letter (*EE, Oct '52, pp 960–1*). I certainly did not intend to disparage either the originators or the users of experimental techniques for the design of nonlinear feedback control systems. I am, as a matter of fact, a user of such experimental methods in my own work.

I feel, however, that if there were a design technique available for use with nonlinear systems, comparable in simplicity with that derived from the theory of linear systems, much expense in money and engineering time could be saved, products might possibly be improved, in the sense of a better approximation to the ideal, and the advance of the art, admirable as it has been, could be accelerated. My own work has indicated to me that such methods can be developed, if research time is applied to the problem.

At the time this article was written, almost a year ago, there was little evidence in the published material that such research into general nonlinear design was being undertaken, while at the same time many new linear design methods were being published. The purpose of the article was to encourage those who do our research to devote some effort towards a general solution for the nonlinear design problem. It is gratifying to note that in the past year several papers have been published, in *Electrical Engineering* and other journals, which indicate that this problem is now getting some attention.

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Correction

To the Editor:

This is a correction in reference to my article, "Probability Method of Finding Reserve Capacity—Effect of Interconnections," (*TP51–198*) which appeared in the October 1951 issue (*EE, Oct '51, pp 876–8*).

I have discovered that the expression for the loss of load P_{ea} given in column 2, page 878, is in error. This equation should read:

$$P_{ea}=\frac{A_a\epsilon^{-a(R_{ao}+R)}}{aL_1}[1-\epsilon^{-aL_1}]+$$

$$\frac{C_2}{b(L_1+L_2)}\left[\frac{\epsilon^{(b-a)R}-1}{b-a}+\frac{\epsilon^{-B_1R}-1}{B_1}\right]+$$

$$\frac{C_2}{b(L_1+L_2)B_1}\{\epsilon^{b(1+L_2/L_1)R}-1\}\times$$

$$(\epsilon^{-B_1R}-\epsilon^{-B_1L_1})+$$

$$\frac{C_2\epsilon^{-bL_2+b(1+L_2/L_1)R-aL_1}}{b(L_1+L_2)(b+B_1)}\times$$

$$(1-\epsilon^{-(b+B_1)R})+$$

$$\frac{C_2\epsilon^{-bL_2-aL_1}}{ab(L_1+L_2)}[\epsilon^{-aR}-1]$$

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